Academy of Denture Prosthetics Meeting. New York City, May 2-6, 1955

THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 5 MARCH, 1955 NUMBER 2

UNIVERSITY OF MICHIGAN
MAR 15 1955
DENTISTRY LIBRARY

Official Publication of

THE ACADEMY OF DENTURE PROSTHETICS

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THE PACIFIC COAST SOCIETY OF PROSTHODONTISTS

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TABLE OF CONTENTS ON PAGE TWO

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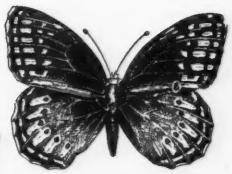

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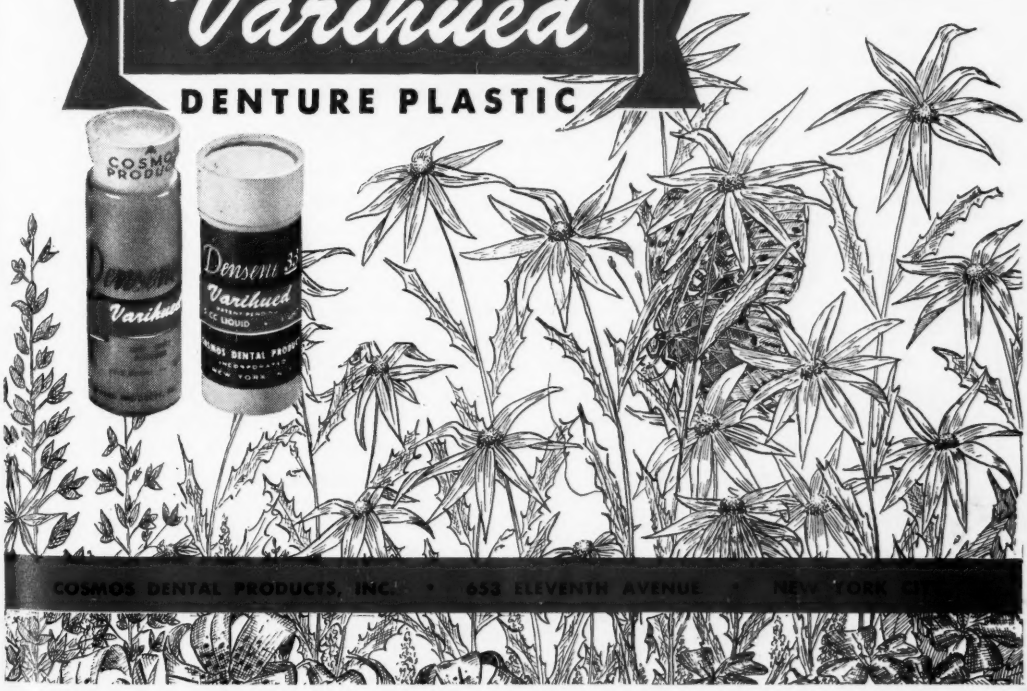

The Journal of Prosthetic Dentistry

CONTENTS FOR MARCH, 1955

Through the Eyes of the Editor. Carl O. Boucher, D.D.S., Columbus, Ohio 145

Presentation of Award to Essay Contest Winner 148

Diagnostic Factors in the Choice of Impression Materials and Methods. George A. Buckley, D.D.S., New York, N. Y. 149

Stabilized Baseplates. Stewart T. Elder, Lieutenant (DC) USN, Washington, D. C. 162

The Kile Dentograph. C. S. Kile, D.D.S., Hutchinson, Kans. 169

Duplication of the Esthetics of an Existing Immediate Denture. E. C. Kelly Geiger, D.D.S., Miami, Fla. 179

Complete Denture Prosthesis for a Case of Acromegaly. Robert H. Sacherman, D.D.S., Youngstown, Ohio 186

Free-Way Space. Alex Coulouriotes, A.B., D.M.D., Arlington, Mass. 194

A Self-Locking Posterior Attachment for Removable Tooth-Supported Partial Dentures. Allison G. James, D.D.S., Beverly Hills, Calif. 200

Investing in the Upper Half of the Flask. G. Newell Wood, D.D.S., Altadena, Calif. 205

Practical Partial Denture Restorations. J. Bernard Hutcherson, D.D.S., Louisville, Ky. 206

Preserving Natural Teeth Through the Use of Clasps. M. M. DeVan, D.D.S., Philadelphia, Pa. 208

Periodontal Aspects of Partial Denture Prosthesis. Ronald B. Nevin, D.D.S. (N.Z.), B.Sc., Dunedin, New Zealand 215

Counterpoise Prosthesis To Correct Excessive Vertical Overlap of Incisors. Blair C. Madsen, D.D.S., Miami, Fla. 220

Cold Cure Acrylic Resin Splints in Occlusal Rehabilitation. Stanley B. Chestner, D.D.S., Mt. Vernon, N. Y. 228

Increased Handpiece Speeds in Restorative Dentistry. Charles M. Chayes, D.D.S., White Plains, N. Y. 232

The Prosthodontist's Role in Cranioplasty. A. H. Grunewald, Captain (DC) USN, Great Lakes, Ill. 235

Trichloroethylene Analgesia. William P. Drew, D.D.S., Brunswick, Ga. 244

Masticatory Forces Associated With the Use of Various Types of Artificial Teeth. Arthur R. Frechette, Captain (DC) USN, Camp Pendleton, Calif. 252

A Method of Measuring Forces of Denture Bases Against Supporting Tissues. W. Ross Stromberg, D.D.S., M.S., Loma Linda, Calif. 268

The American Denture Society Prosthetic Essay Contest

Announcement and Rules 289

News and Notes

News and Notes 291

Vol. 5, No. 2, March, 1955. Journal of Prosthetic Dentistry is published bi-monthly by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription Price: United States and its Possessions per Year $9.00; Canada, $9.25; Foreign, $10.00. Entered as second class matter March 13, 1951 at the Post Office at St. Louis Missouri, under the Act of March 3, 1879. Additional entry authorized at Jefferson City, Missouri. Printed in the U. S. A.

THE JOURNAL OF PROSTHETIC DENTISTRY

Vol. 5 March, 1955 **No. 2**

THROUGH THE EYES OF THE EDITOR

George A. Buckley classifies the various techniques for making impressions for complete dentures and discusses the various diagnostic factors involved in the proper selection of the technique to use for each situation that may be encountered. He places proper emphasis on the importance of choosing the right impression procedure for the best control of the conditions that exist in each mouth. While some of the suggested procedures may be subject to criticism, the basic principle of the selection of the material and procedure to meet the varying conditions found in different mouths is sound.

Stewart T. Elder discusses a phase of complete denture techniques which is given too little attention by too many dentists. The baseplates, which are the foundations for occlusion rims on which the jaw relations are recorded and on which teeth are arranged for the try-in in the mouth, are frequently inadequate. These facts are made clear in this discussion. The purposes and requirements of baseplates are listed and discussed. The various materials and methods available for making baseplates are described and compared on the basis of their adequacy and convenience of construction. The comments regarding terminology are worthy of further study.

C. S. Kile describes the use of his articulator. The instrument is unique in that it is a combination jaw relation recording device and a tripod type of articulator. The technique includes the use of occlusion rims which are built up with abrasive occluding surfaces. The patient rubs these surfaces together to shape them in harmony with each other and to determine the occlusal curvature. With these surfaces maintaining the vertical separation of the jaws, extraoral three dimensional tracings are made in wax, and these tracings are duplicated in stone to form the articulator guidances. Theoretically the procedure seems to be sound, but the chew-in procedures used in the formation of the occluding surfaces will cause some shifting of the baseplates in relation to the supporting bone. Any errors produced in this manner will be magnified in the extraoral tracings and in their stone replicas. It is possible that if positional records, instead of functional records, were made, that the guidances would be more accurate. The equipment would make possible the use of numerous vertical closures in many different positions for the development of the extraoral records. This would eliminate the side shift of the bases during the formation of the extraoral records. It is not clear how cusps (if any) are retained on the teeth when no apparent provision is made for cusp height when the registrations are made. It would seem that all cusps would be eliminated if the teeth were made to conform to the articulator guidances which are dictated by the chewed-in occluding surfaces of the occlusion rims. The instrument and the technique are most interesting and stimulating to thought about the various factors involved. The procedure is not as complicated as it might seem. It is worthy of serious study.

E. C. Kelly Geiger describes a technique for making a denture which duplicates the esthetics of an existing denture. The technique is a modification of procedures which are commonly used in immediate denture construction combined with a relining impression procedure. It is apparent that the objectives of duplicate dentures with a minimum of disturbance to the patient can be achieved by the procedure he suggests.

Robert H. Sacherman reports the case history and prosthetic treatment of an edentulous acromegalic patient. This essay won the first prize in the essay contest for senior dental students which is sponsored by the American Denture Society. He is to be congratulated for his success.

Alex Coulouriotes has written an excellent review of the literature relating to the free-way space. This essay won the second prize in the essay contest for senior dental students sponsored by the American Denture Society. He is to be congratulated for his success.

Allison G. James describes the technique for making an attachment for tooth-supported removable partial dentures which requires no spring tension or friction for its effectiveness. It is a practical and effective retainer when it can be used. It is usable only when the vertical space available for the pontic is small.

J. Bernard Hutcherson discusses the engineering involved in the design of partial denture restorations. He insists that partial dentures need not cause the loss of abutment teeth if they are propertly designed. Certainly they will cause the destruction of these teeth if they are *not* properly designed. He emphasizes the importance of a special consideration for the occlusion of partial dentures. There may be some question of the use of weak teeth as abutments, except when they are splinted together, and even then good judgment must be used. We doubt the advisability of constructing clasps without occlusal rests under any circumstance.

M. M. DeVan discusses the way natural teeth may be preserved in spite of the use of clasps on partial dentures. He points out the advantages and disadvantages of clasps in general and compares the effects on the health of teeth with various types of clasps. The stabilizing action of clasps can be used to the advantage of abutment teeth if the clasps are properly designed. We agree that stability is more important than retention and that retention should be secured wih the minimum tension on the abutment teeth. The main consideration in the design of clasps should be the effect on the health of the clasped tooth. The subconscious preference for a certain type of clasp may lead to the use of clasps which destroy the abutment teeth.

Ronald B. Nevin discusses the periodontal aspects of partial denture prosthesis and the various means for maintaining and improving the health of the periodontal structures of the abutment teeth. He cites irritation of the gingival tissues by the restoration as a major source of trouble and suggests that it is bad practice to cover the free gingivae closely. This seems to be a sound observation. He describes a type of appliance which is designed to minimize gingival irritation. The pontic section of the removable appliance is similar in form to the "sanitary pontic" formerly used in fixed partial dentures. It should accomplish the results he sets out to achieve, but it seems to be deficient in esthetic possibilities.

Blair C. Madsen describes a means for providing a posterior balancing support for patients with a deep vertical incisal overlap in their natural dentitions. The appliance is used where modifications of the occluding surfaces by grinding will not suffice and where the vertical dimension of occlusion may not be increased. It consists of a balancing ramp built on restorations in molar teeth which are splinted together. This should protect the anterior teeth from destructive forces, but it is imperative that a perfect balance between the anterior and posterior tooth contacts must be developed. A premature contact on a balancing ramp would develop traumatogenic forces on the posterior teeth and might cause temporomandibular joint disturbances. Care must be used in the use of this appliance.

Stanley B. Chestner favors the use of cold-cure acrylic resin splints over other types of splints used in occlusal rehabilitation. He lists their indications and describes a technique for their construction. Their advantages seem to outweigh their disadvantages when they are used as temporary or treatment appliances.

Charles M. Chayes discusses the use of increased speeds of the rotating instruments used in preparing teeth for restorations. He supplies data regarding the relation of the size of the instrument, the rotating speeds, and the surface speed of the cutting surface. This should prove to be a guide in the choice of the handpiece speed which is most efficient

for a given operation. He points out the precautions which must be used with high speed instruments. He reports that he has observed many advantages to himself, as the operator, and to the patient when high rotational speeds are used with the proper care but urges that this innovation be given a more complete trial and investigation.

A. H. Grunewald discusses the various materials used in making calvarium plates and describes the technique for making them of methyl methacrylate in clear and concise detail. He feels that the advantages of this material over the others are sufficient to make it the material of choice. The use of this material makes the role of the prosthodontist in cranioplasty become extremely important. The techniques used are familiar to the prosthodontist, but the nature of the work requires special precautions as to sterility and perfect cooperation with the surgeon.

William P. Drew recommends the use of trichloroethylene analgesia in restorative dentistry and describes two methods by which it can be used. The apparatus and the techniques do not seem to be too complicated to be practical. While it is not intended to be a substitute for anesthesia, it could be of value in minimizing pain in operative dentistry. Obviously, it must be used with care and only by those who have an adequate training in physiology to understand its dangers.

Arthur R. Frechette makes a preliminary report on the masticatory forces associated with the use of various types of teeth. The preparations preliminary to the measuring of forces applied to the supporting tissues by dentures were carried out in exacting detail. The test denture base with the interchangeable occlusal schemes were constructed with adequate attention to uniformity of all factors except the forms of the occlusal schemes which were to be compared. The location of the strain gages in the test bases was adequate for testing for lateral and vertical forces. The tests could have been more complete if strain gages had been located also on the lingual and labial sides of the anterior segment of the ridges. It is unfortunate that the test method described is so complicated and so expensive in time, effort, and equipment that not many investigators will be able to attempt similar experiments. It is unfortunate that so much work is required preliminary to making tests for one patient. However, this does not nullify the validity of the method. The conclusions derived from the tests made on only one patient are properly made with reservations. Except for the "observations of the patient," the work is objective and is a sincere effort to find out the truth. Opinions expressed by patients in these test situations are of little value. The measurements of forces by electronics and the measured chewing performance tests can be of great value if they are properly interpreted. Much more true research of this nature is needed in order that the vexing problems of occlusion can be solved.

W. Ross Stromberg describes a method of measuring the forces that denture bases exert against their supporting tissues while in function. This is a pilot study directed toward finding a satisfactory method for measuring these forces. Electronic equipment was adapted to the requirements of the testing. Three test foods were used with two kinds of teeth, and the forces exerted by the dentures in different directions were measured. This test method seems to be a valuable addition to others which are used for the study of the direction and magnitude of the forces of mastication with different kinds of teeth and different foods. Further use of this method should provide valuable scientific data from which valid conclusions can be drawn. It is a means for taking one step further away from mere opinion and conjecture.

—Carl O. Boucher

PRESENTATION OF AWARD TO ESSAY CONTEST WINNER

Dr. Robert H. Sacherman (right) is shown receiving his prize, a $500 check, from Dr. Samuel S. Cohen, president-elect of the American Denture Society. The presentation of this first prize in the 1954 American Denture Society Essay Contest for senior dental students was made at the December meeting of the Cleveland Dental Society in the Hotel Hollenden.

Dr. Sacherman's prize-winning essay appears on page 186 of this issue of the JOURNAL OF PROSTHETIC DENTISTRY.

DIAGNOSTIC FACTORS IN THE CHOICE OF IMPRESSION MATERIALS AND METHODS

GEORGE A. BUCKLEY, D.D.S.*

New York University College of Dentistry, New York, N. Y.

MOST OF THE MANY impression materials and impression methods can be used to the best advantage if they are applied to patients for whom they are indicated. No particular technique or special material will solve all of the problems. Results can be expected only in proportion to the operator's knowledge, skill, and judgment, based upon practical experience, and the use made of the various impression materials. If these materials are used where they are indicated, more consistently good results in impression making and, perhaps, a higher percentage of successful dentures may be expected.

More than half of the edentulous patients can be cared for adequately by almost any impression procedure that will give a fair degree of accuracy. The other 40 to 50 per cent, however, require special consideration and are the problem patients. It is with this 40 to 50 per cent of the denture patients that we can see the improvement in our results when care is exercised in selecting the impression procedure and material that is most suitable. Of course, there are some patients who will never be happy and content with complete dentures. Some patients present us with such inadequate denture-bearing areas, coupled with poor tissue tolerance and a pessimistic attitude, that no prosthodontic skill or judgment could overcome them. Despite all our efforts there will be some failures, but we do try to reduce the failures to a minimum and to make these patients feel at least pleasantly disappointed with the results. Greater success can be attained with problem denture patients when the treatment planning, especially for the impression procedure, is carefully carried out.

CLASSIFICATION OF IMPRESSION TECHNIQUES

Modern impression techniques may be classified in two ways.[1]

I. According to the position of the jaws in relation to each other when the impressions are being made.

A. Closed mouth.

B. Open mouth.

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 14, 1954, and before the American Denture Society, Miami Beach, Fla., Nov. 5, 1954.

Received for publication July 27, 1954.

*Professor and Chairman of Department of Denture Prosthesis.

II. According to the degree of pressure applied when the impressions are made.

A. Positive pressure.
B. Negative pressure.
C. Selective pressure.
D. Nonpressure.

The rationale behind the closed mouth impression procedure is the idea that normal muscle movements by the patient will adapt the impression material more accurately to the anatomic limitation when the mouth is closed and under pressure.[2] There are various degrees of biting pressures, however, and it is very difficult to have any two patients agree on what is light or what is heavy pressure. It is also difficult for the patient to use the same degree of biting pressure while the maxillary impression is made as when the mandibular one is made.

Since the dentist has greater control over the pressures used in making open-mouth impressions, this tends to influence him toward the choice of this procedure.

Because there are different degrees of pressure that can be applied in making edentulous impressions, there must be definite objectives in the selection of the amount of pressure used. If a positive pressure procedure is decided upon for a given patient, the objective is to obtain a certain degree of even and equal tissue placement in making that impression. Likewise, if a nonpressure procedure is indicated, the objective is to avoid any tissue displacement in making the impression.

CHOICE OF IMPRESSION TECHNIQUES

The impression procedure that is indicated for a given patient could be determined accurately only after a thorough visual, radiographic, and digital examination of the jaws and adjacent structures. After this examination has been completed, the findings are evaluated, and the diagnosis, prognosis, and plan of treatment is selected. The diagnosis will determine: (1) the procedure to be followed in making the impressions and (2) the impression material that is indicated to best accomplish our objectives.

RETENTION AND STABILITY

Let us arbitrarily assume that every denture should possess three different and distinct types of seal.

1. A *tissue seal exists* when the denture base has an equalized intimate contact with the palatal area and the crest, labial, and buccal sides of the ridge. It is a basal seat seal.

2. A *ridge seal* exists when the denture base is sealed to the labial and buccal sides of the ridge at the labial and buccal borders and along the posterior border of the denture.

3. A *border seal* exists when the denture border completely fills the mucobuccal space and buccal pouch, and seats itself against the cheeks (Fig. 1).

Many dentures exhibit good stability, evidently possess an adequate tissue seal, but are obviously lacking an adequate ridge or border seal; and they have little retention at insertion.[3] Patients are completely unappreciative of all the efforts exerted during denture construction when, at completion time, their dentures display little retention. It certainly does not develop patient confidence, to say the least. To hope that settling will intrude the denture base into the mucosa and improve retention does not impress many patients who are dissatisfied, and certainly it does not restore lost confidence. How often have we heard a patient remark later, "Doctor, these dentures didn't fit from the very first day I received them."

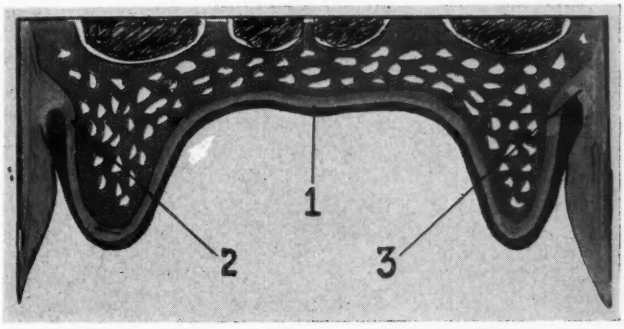

Fig. 1.—The three types of seal: 1, Tissue seal; 2, Ridge seal; 3, Protective border seal.

It is important that dentures exhibit retention and stability in the very beginning. And yet some men contend that the only seal necessary to retain a denture is a tissue seal where "interfacial surface tension operates by virtue of a thin fluid film between two intimately contacted objects."[4] This contention has not stood the test in clinical experience, and we still think that a denture should possess the three areas of seal just mentioned to have the maximum of retention and stability.

DIAGNOSTIC FACTORS

The main diagnostic factors influencing the choice of edentulous impression materials are:

1. The soft tissue condition which involves the type of mucoperiosteum that covers the denture-bearing areas. (These soft tissue conditions will be classified according to their depth and type of attachment to the periosteum.)
2. The ridge shape. This refers to the shape and contour of the denture-bearing surfaces of the ridges.
3. The palate shape. This factor requires consideration of the vertical and horizontal contours of the palate.
4. The mucobuccal fold. This factor concerns the relation of the muscle attachments and the reflected mucous membrane to the ridge crest.
5. The size of the denture-bearing area. This involves the total tissue surface that is available for coverage and that should be included as the denture-bearing area.

Fig. 2.

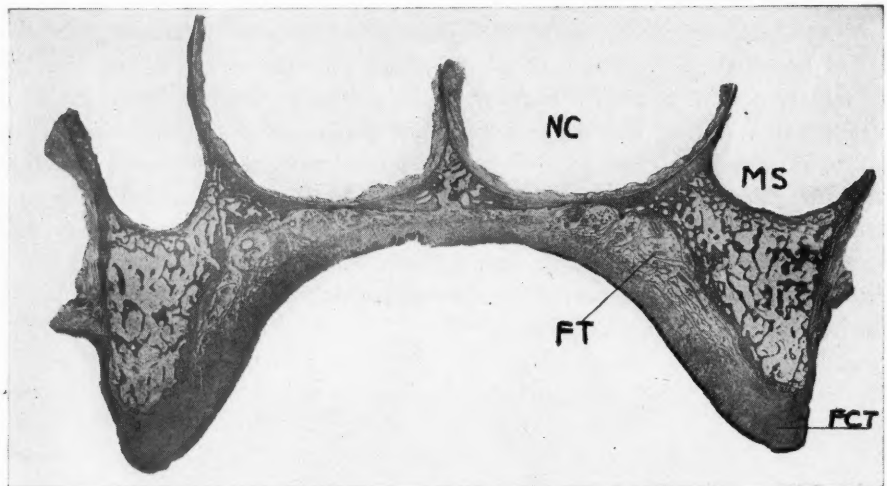

Fig. 3.

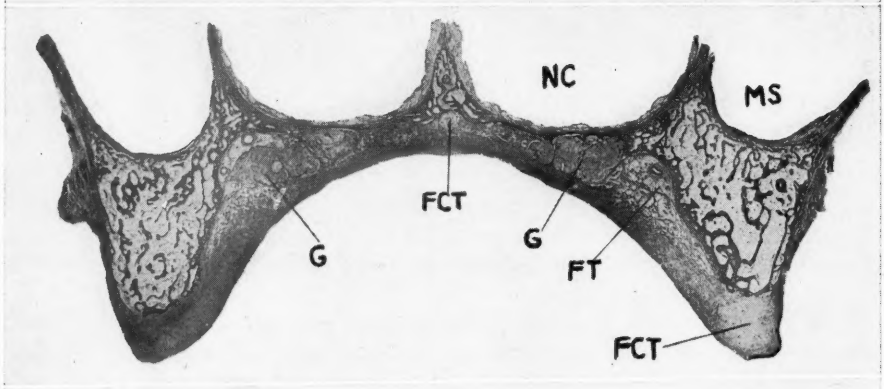

Fig. 4.

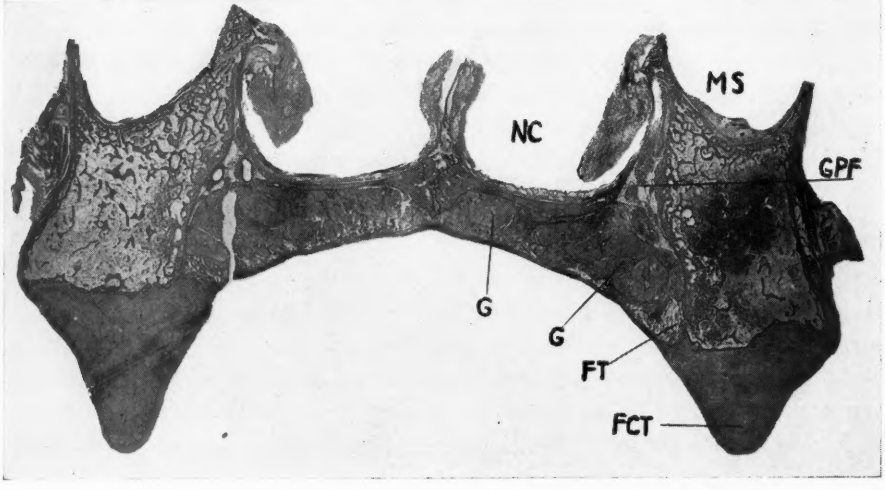

Fig. 2.—This histologic section through the first molar region displays a very thick covering of fibrous connective tissue over the vault and ridges.

Fig. 3.—This histologic section through the second molar region shows definitely divided regions of fibrous connective tissue, fat cells, and glandular tissue. The fibrous connective tissue is confined to the ridge area and maxillary suture.

Fig. 4.—This histologic section through the posterior border of the tuberosity shows the osseous framework as a block formation which is cancellous. A pendulous area of fibrous connective tissue covers the ridges.

SOFT TISSUE CONDITIONS

"A study of the histologic structure of the soft tissues of the upper jaw reveals the relative ability of the various areas to withstand pressures. The crest of the upper ridge is covered with fibrous connective tissue which is usually closely attached to the bone."[2] (Figs. 2, 3, and 4.) Visual examination and palpation may show that:

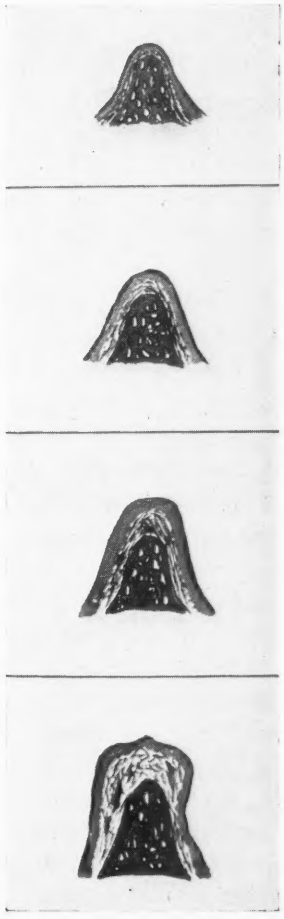

Fig. 5.—Mucosal thickness with any ridge form. These drawings show a comparison of various types of soft tissue covering over ridges. Note the thin layer of mucosa and the thin submucosa in the ridge with minimal mucosal thickness (*A*). The vascular supply is very sparse and is derived mainly from the underlying bone. This type of ridge can withstand heavy pressures without destruction.

The submucosal tissue thickness is greater in the ridge with average mucosal thickness (*B*). Note the presence of the keratinized or cornified epithelial layer. These tissues are closely attached to the underlying bone and can also withstand pressures.

The heavy and movable mucosal thickness shows an increased depth of the submucosa (*C*). Sometimes these tissues are readily movable, and their displacement can cause a stasis of the blood supply and bring about an osteoclastic activity in the cortical layer of the bone.

Hypertrophied tissue which must be well supplied with blood vessels to sustain this heavy overlying tissue (*D*). These tissues are very easily displaced. Their displacement can cause a stasis of the blood supply and bring about more osteoclastic activity and further destruction of cortical bone.

1. The denture-bearing area is very hard and unyielding with a very thin mucosal covering. In other words, this type of mouth is one that presents hard areas all over and in which tissue placement would definitely be indicated in order to obtain the full benefits from adhesion (Fig. 5).

2. The patient has an average amount of connective tissue covering, with average tissue resiliency. This type of patient presents a combination of hard areas and soft areas with tissue placement desirable in order that the soft tissues may share the load equally with the hard areas (Fig. 5).

3. The palatal and ridge areas of the mouth are covered with a heavy pad of mucoperiosteum that is not firmly attached to the underlying bone and is readily movable. Tissues in this type of mouth would be considered soft and displaceable, and, therefore, pressure in the impression would obviously be contra-indicated (Fig. 5).

4. The residual ridges of the patient are covered with hyperplastic or hypertrophied tissue which is extremely displaceable (Fig. 5).

CHOICE OF IMPRESSION MATERIALS

It is obvious that the same impression material would not be indicated for the soft tissue conditions of each of these patients, but rather a material should be selected that would be suitable for the conditions in each mouth.

1. Where the soft tissues are hard, a resistant material, such as modeling compound, would be preferred for the preliminary impression. The final impression could be made in a confining individual tray made of an activated resin, using medium fusing compound as the final impression material to obtain even and equal tissue placement.

2. Where the tissue is of average resiliency and tissue placement is desirable, modeling compound may be used for the preliminary impression. The final impression may be made in a confining rigid resin tray, using a zinc oxide and eugenol paste or a similar material of average resistance. This is done in order to have an equalized impression where soft tissues share the load equally with the hard tissues.

3. Where the tissues are readily movable, a freely flowing irreversible hydrocolloid or some similar nonresistant material would be indicated for the preliminary impression. This material is used in order to avoid any displacement of these movable tissues in making the impression. The final impression could be made in a perforated activated resin tray using a freely flowing zinc oxide and eugenol paste (powder and liquid form). The use of a perforated or unconfined tray permits the slight pressure applied in making the impression to be dissipated. The excess impression material is allowed to escape through the perforations in the tray during the flow, and while the material is setting slowly.

4. Where the tissues are extremely hypertrophied, a soft free-flowing alginate material is indicated for the preliminary impression. The final impression could be made in a perforated tray to dissipate the slight pressure that might be applied in making the impression.[6] The final impression material could be a freely flowing alginate or a thin mix of plaster of Paris.

RIDGE SHAPE

The ideal ridge is broad, high, and has buccal sides which are parallel to each other. If the ridge shape is parallel-sided, the routine pressure or nonpressure procedure does not require modification or alteration because adequate tissue, ridge, and border seal would be obtained for retention and stability (Fig. 6). On examination of the patient, however, conditions varying from the ideal may be encountered.[7]

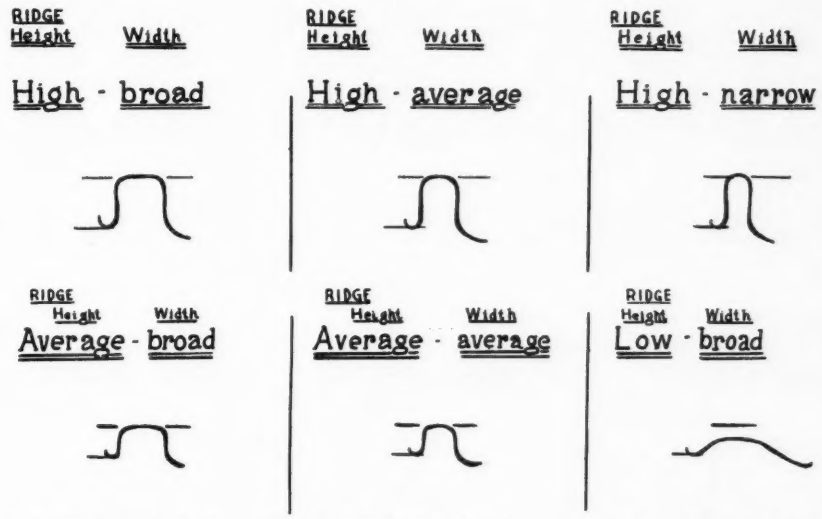

Fig. 6.—The various types of parallel-sided ridge forms that we may encounter. The broad-crested parallel-walled ridge is the most retentive of all. It is a combination of the longer parallel walls and the broad crest. The retention is not very great in a parallel-walled thin ridge because of the small area at the crest of the ridge. Even though the parallel walls of the denture hug the sides of the ridge and create some slight vacuumatic space, this is too small to account for much of the retention.

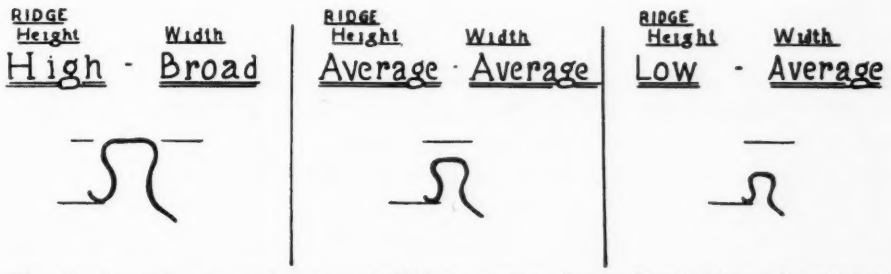

Fig. 7.—Careful surgery is recommended to remove the undercuts from diverging-sided ridge forms to make the walls as parallel as possible.

1. The ridges on each side may be diverging from one another, presenting undercuts in several locations. This would prevent the obtaining of a well-sealed impression around the denture border because the prominent points are likely to be readily irritated (Fig. 7).

2. The sides of the ridges on each side may converge toward each other and present a V-shaped appearance. This type of ridge is highly unfavorable

because, the moment the denture moves downward, it leaves the entire ridge at once and falls out (Fig. 8).

3. Ridges may be very high but extremely narrow and present an unfavorable and limited denture-bearing area. Although the sides of the ridge may be parallel, the crest is too small to afford much retention or support for the denture (Fig. 9).

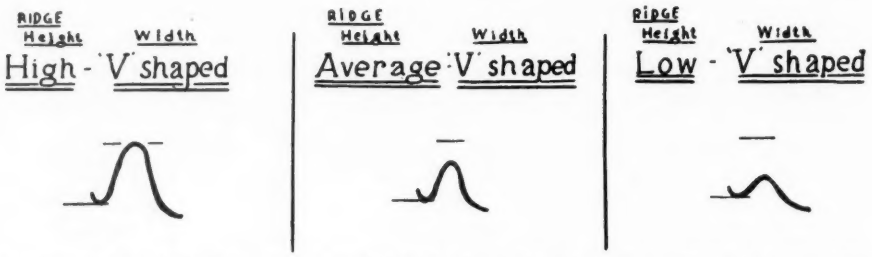

Fig. 8.—V-shaped ridge forms are probably the least retentive type. There is no parallelism and, at the slightest movement of the denture, the base loses contact with the sides of the ridge, and retention is lost.

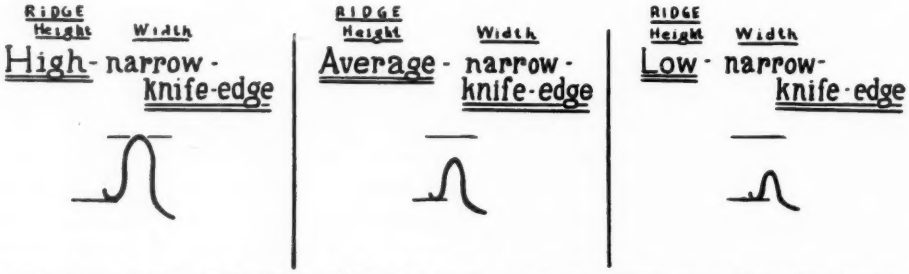

Fig. 9.—A sharp knife-edged ridge frequently requires surgery to reduce the height of the ridge and remove the sharp spiny process. If surgery is contraindicated, special treatment is required in making the impressions.

The presence of any one of these ridge conditions may indicate a modification of the impression procedure, as well as the materials previously selected on the basis of the soft tissue conditions; for example, a jaw may present a narrow or average V-shaped ridge and, at the same time, be covered with tissue that has excessive depth and is easily displaced. The selection of a nonpressure impression material on the basis of excessive depth and movability of the tissue may have been decided upon in order to avoid tissue displacement. It may, however, fail to provide for sufficient tissue placement at the denture border of this V-shaped ridge to counteract the loss of seal due to the slightest movement of the denture. It would be advisable, therefore, to utilize a material, such as modeling compound, around the border and on the tissue side of the border of the impression tray in order to obtain sufficient tissue placement in those regions. The final impression would then be made in a perforated activated resin tray,[8] using the material previously selected to avoid tissue displacement, such as thin plaster of Paris, or zinc oxide and eugenol (powder and liquid).

On the other hand, the patient may present with average connective tissue resiliency covering the ridges and, if no other factors would have to be considered,

a pressure impression procedure may be indicated. At the same time, however, this patient may have a high knife-edged ridge form. The presence of this sharp edge on the ridge crest should influence the choice of a nonpressure impression procedure in order to avoid even a slight stretching of the mucosa over the sharp bony process.

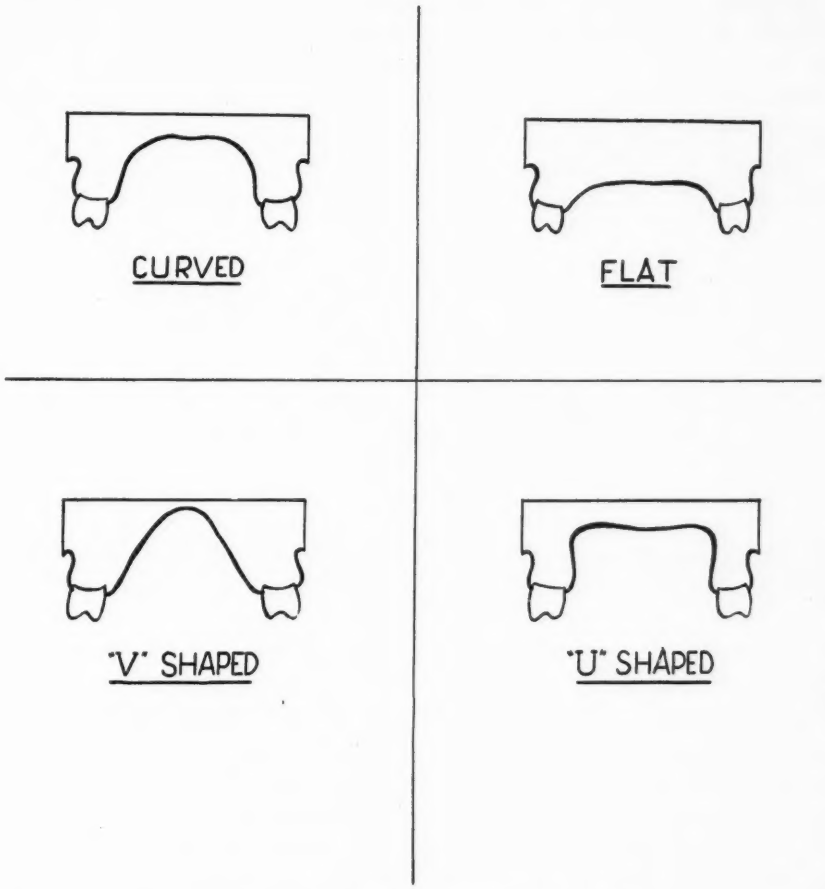

Fig. 10.—The different types of palate forms.

PALATE SHAPE

The shape of the palate will influence the amount of tissue seal that may be obtained from adhesion (Fig. 10).

1. The U-shaped palate, having parallel palatal ridge sides and a broad base, offers the best tissue seal for retention and stability. The type of impression material and the technique used for this palate shape are not likely to require modification.

2. The curved palate has longer palatal ridge sides, but has a narrower base, and is not as favorable as the U-shaped palate. Additional retention may be obtained in this type of palate by increasing the ridge and border seal, especially if the tissue condition indicates nonpressure materials and technique.

3. The flat palate shape has a broad base, but the ridge sides are lower. This type of palate shape carries a potential threat to retention, because there is little resistance to lateral stress, and skidding of the base is readily induced. Here also, additional ridge and border seal may be necessary to develop more retention.

4. The high V-shaped vault, having greater vertical than horizontal area, offers the least retention by adhesion for the denture. The converging palatal sides provide no parallelism and have a narrow base at the region of the median suture. The presence of this type of vault allows only the minimum of tissue seal; therefore, care should be taken that adequate *ridge* and *border* seals are obtained in making the impression, in order to compensate for the lack of tissue seal. The ridge seal will increase retention by adhesion, and the border seal will take advantage of atmospheric pressure as an aid to retention.

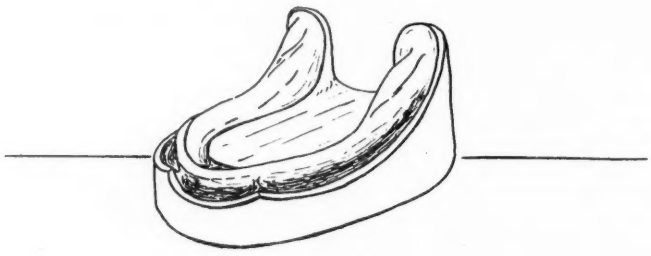

Fig. 11.—Note the high attachments of the frenula and the buccinator muscle which are close to the ridge crest. Note also that the entire mucobuccal fold is close to the ridge crest. This condition may exist in either the mandible or the maxilla.

THE MUCOBUCCAL FOLD

Denture borders are usually extended to the turn of the mucobuccal flexure and allow sufficient relief for muscle attachments (Fig. 11). In those mouths where the mucobuccal fold is close to the ridge crest, however, the extension of the denture borders in this region is limited. The shortened flanges do not provide the ridge seal and border seal that might be desired. Therefore, in making impressions for this type of mouth, it is necessary to obtain the maximum amount of border extension that is possible in order that a satisfactory ridge and border seal may be secured. This seal must be adequate if we hope to increase the lateral retention of the denture base. Therefore, it may be advisable to employ an impression material that will aid us in our uncertain limitation of extensions in these cases. There are several zinc oxide and eugenol paste materials and others (Adaptol) that would be useful.

SIZE OF THE DENTURE-BEARING AREA

It is known that the stability of a denture base and its ability to withstand biting pressure are in direct proportion to the size of the area upon which the denture rests. Any reduction in the size of the area covered would tend to produce a corresponding reduction in stability and retention of a denture (Fig. 12).

1. Patients with a Class III throat form, where the soft palate drops abruptly from the hard palate, afford a very narrow postdam area and also a shortened anteroposterior denture length. This shortening reduces the size of the denture-bearing area and, therefore, reduces retention.

2. A small inter-ridge space that does not permit complete coverage of the retromolar tubercle (tuberosity) also reduces the size of the denture-bearing area and retention.

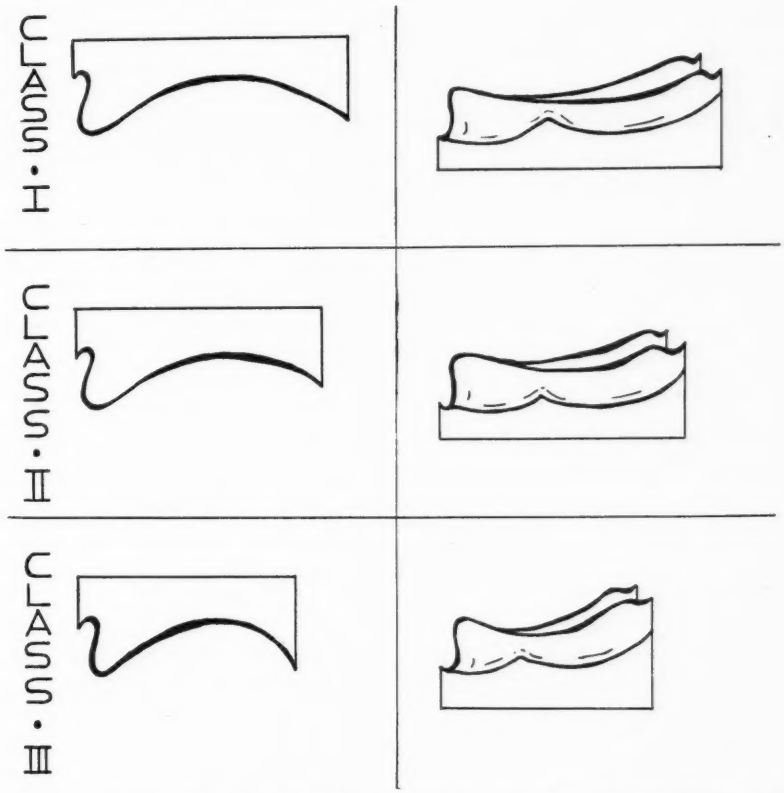

Fig. 12.—The denture base coverage is reduced in the Class II and Class III maxillary arches because of the throat form. It is reduced in the Class II and Class III mandibular arches because of their shorter anteroposterior length, and in Class III because of the impossibility of covering the retromolar pad completely on account of interference with the upper denture.

3. Mouths where the maxillary or mandibular ridges have completely resorbed and where there are no buccal ridge sides remaining have a very much diminished denture-bearing area and offer little chance of retention. In all cases of reduced area of coverage, it might be advisable to use an additional impression material at the denture border to obtain adequate ridge and border seal. This addition will aid denture retention, thereby stabilizing the denture base against lateral skid, and will improve the lateral retention of the denture.

Therefore, it becomes increasingly evident that an evaluation of all of these factors is necessary if we are to select the impression procedure and material which are best suited to the needs of the individual patient and which will produce the best results for that patient.

RELIEF AND POSTDAM

Regardless of the impression procedure or material used, a postdam is provided on every maxillary denture. None is used on the mandibular denture. The termination of the posterior border of the maxillary denture base is located in the patient's mouth and marked with indelible pencil. This marking is transferred to the cast by means of the activated resin tray. The post damming is accomplished on the cast in every instance. The depth and width of the postdam will, of course, vary with the individual case. Likewise, the relief areas that are provided must be accomplished differently when different impression materials are used. The outline for the relief of the torus palatinus and the incisive papilla is marked in the mouth and transferred to the impression. The relief is then cut away from the finished impression if possible. If it is not possible to cut a relief in the finished impression, a metal relief is cemented on the final cast.

After evaluating all of the factors that should be considered and having decided, for example, that a pressure type impression procedure is indicated, then this principle of even and equal tissue placement should be strictly adhered to. It should be instituted in the primary or preliminary impression and should then be faithfully carried out through all stages of making the impression.

Likewise, if tissue displacement is to be carefully avoided, then *this* principle should be incorporated in the preliminary impression and carried out during the entire impression procedure if we hope to obtain our objectives. In this latter case, it is obvious that modeling compound would not be the material of choice in making the preliminary impression *unless* a relief is made in that impression or on the preliminary cast and a shim or oversize tray is used for making the final impression.

In any event, whether a pressure procedure or a nonpressure procedure is decided upon, the principle of full denture-bearing area coverage, border extension, and muscle trim are still maintained. That means that the maxillary denture should cover the labial and buccal sides of the ridges to the turn of the mucobuccal fold, allowing for sufficient relief at the denture border for the muscle attachments but providing sufficient width to the border to fill the buccal space completely. The palatal area is entirely covered back to the posterior border, which is terminated behind the tuberosities at the region of the pterygomaxillary notch and in the median line at the region of the foveola palatini or vibrating line.

The mandibular denture should cover the labial and buccal sides of the ridge to the turn of the mucobuccal fold, but making allowance for sufficient extension into the region of the buccal pouch. Provision for relief of muscle attachments should be made. Posteriorly, the denture should cover the retromolar pad completely if possible (Fig. 12). Lingually, the extension and direction of the flange is determined originally in the preliminary impression by using a material that would provide for a physiologic determination of that border. This flange is then further corrected for adaptation and detail in the final impression.

SUMMARY

The making of impressions for edentulous mouths may not be the most important phase in complete denture construction. It should require, however, the same careful planning as the other steps in complete denture procedures. A knowledge and an evaluation of the various biologic and diagnostic factors of the individual patient should influence the treatment planning of the impression procedure. These factors have been discussed and the variations in impression procedures, as have been indicated in each situation, have been suggested.

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STABILIZED BASEPLATES

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LITERATURE IS very voluminous about the theories and techniques of recording centric relation. There are nearly as many methods as there are writers in the field of dental literature. Gysi[1] stated, "Ever since full denture work began dentists have been devising ways of getting the mandible into centric relation to the maxilla, and hundreds of methods which differ slightly from one another have been developed." Literature is lacking in any comprehensive study of baseplate, trial base, or what every one prefers to call the bases upon which maxillomandibular records are made. It is generally believed that proper baseplates are important in denture prosthesis. House[2] states, "Almost universal inaccuracy in the art of making dentures is evident in the bite plate used for registering maxillary and mandibular relations." Kyes[3] states, "One of the main reasons for faulty centric occlusion in the finished denture is the failure to use properly stabilized baseplates." Block[4] states, "Very few complete denture patients are given the consideration or admission by the dentist that his records may be wrong at the mounting stage. Far too many rims for complete dentures are loose and ill-fitting, and in this unstable state, slip and slide off their bases."

It is evident that the dental profession has realized the importance of proper baseplates; but it is also just as evident that the profession, generally, has done little to improve the bases upon which they record maxillomandibular relations. The probable reasons for the almost universal use of poor baseplates are: (1) The lack of knowledge of the requirements of proper baseplates. (2) The relative unimportance given the baseplate in dental literature. (3) The lack of emphasis of the importance of baseplates in most dental schools.

It might be well before the discussion goes further to consider the terminology so that throughout the discussion there will be no confusion.

The dictionary defines stabilize as: "Equalize—to make stable or, in dentistry, to seat or adjust a bridge or denture so that it will not tilt or be misplaced under pressure." It defines baseplate as: "A temporary form to represent the saddle or base of a denture." From the definitions, it would seem that a stabilized baseplate is one that started with a baseplate, such as baseplate gutta-percha. Then something was added to make the baseplate stable, such as a liner of zinc oxide paste or cold cured acrylic resin.

The question arises, is it possible, by adding a liner to a baseplate, to make the base stable, or is the retention being enhanced by a closer adaptation of the

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The opinions and conclusions contained herein are those of the writer and do not necessarily reflect the official views of the Department of the Navy nor of the Department of Defense.

Received for publication June 25, 1954.

base to the mucoperiosteal surfaces? DeVan[5] states, "The impression, however, is a minor factor in the problem of stabilizing a denture. The important problems are: (1) The inclination of the flanges. (2) The position of the posterior teeth in relationship to the foundational center. (3) The form, size, and arrangement of the posterior teeth. (4) The form of the polished palatal surface."

Boucher[6] states, "Stability is based on the resistance to horizontal movement of the denture. Stability is necessary to resist forces of occlusion in both centric and eccentric positions. It is attained by utilizing the surfaces that are at or near right angles to the occlusal plane. These surfaces might not be at a favorable angle and the soft tissue over them might be too soft in cases for ideal results."

TERMINOLOGY

It appears that a baseplate or denture base is not entirely dependent upon close adaptation of the base to the mucoperiosteum for stability. There are other factors as mentioned that are more important in the stabilization of baseplates or denture bases. So it seems that adding a liner to a baseplate will not necessarily stabilize it. Since a liner to a baseplate does not stabilize it, and because of the connotation the dental profession has applied to the words stable, stability, and stabilize, it probably would be better terminology if "stabilize" were dropped from the term "stabilized baseplates." Baseplate or record base could be used to designate a properly constructed base for recording maxillomandibular records. Record bases might be better terminology than baseplate, and is presented for consideration. Denture base is recognized as the correct terminology for the material which forms the base between the mucoperiosteum and the teeth. McCracken[7] has suggested that "trial base" be used to designate the base upon which the trial setup of the teeth is made. It would seem that record base would be the correct terminology since it would be in line with the other two terms. Thus the three terms would be: (1) *Record base* for recording the necessary maxillomandibular relations. (2) *Trial base* for making a trial setup of the teeth. (3) *Denture base* for base material which holds the teeth and adapts the mucoperiosteum.

The terms *record base* or *baseplate* will be used to designate bases upon which jaw relations are recorded throughout the remainder of this discussion.

THE PURPOSES OF RECORD BASES

To increase the quality of denture prosthesis, it is advisable to understand the purpose, the requirements, the advantages, and the disadvantages of any one phase of denture construction.

The purposes of record bases and trial bases are[8]: (1) To act as carriers for occlusal rims upon which jaw relations are recorded. (2) To hold the teeth in the wax setup for the trying-in stage. (3) To check the accuracy of the previously recorded records.

The accuracy of the records and all subsequent phases depends upon the quality of the baseplates. Failure to recognize that the jaw relations records are

no better than the bases upon which they are recorded, may well be the reason that the centric occlusion of so many full dentures is not in harmony with centric relation.[9]

REQUIREMENTS OF RECORD BASES

The requirements of record bases are that they must: (A) adapt to the basal seat area as the finished denture base; (B) have the same border form as the finished denture base; (C) be sufficiently rigid to withstand biting forces; (D) be dimensionally stable; (E) be constructed so that they may be used as bases for setting up teeth; (F) be possible to fabricate inexpensively, easily, and quickly; (G) have no undesirable color.

A. *Adapt to the Basal Seat Area as the Finished Denture Base.*—The material and technique used for fabricating a record base should be such that it will perfectly adapt to the mucoperiosteum of the basal seat area. This close adaptation to the tissue will increase the retention by reducing fluid film thickness as has been suggested by Skinner[10] and Stanitz. Also, an error in the impression can be detected at a time when it can be remedied with very little extra effort. If the record base does not meet the requirements of the finished denture base, it can be used for a tray to remake the impression.

B. *Have the Same Border Form as the Finished Denture Base.*—A record base having the same border form as the finished denture base will give the operator an opportunity to test the retention and stability of the finished denture. The correct border form increases the retention by perfecting the border seal, and by allowing the tissues to drape over the borders of the record base so that they will cause a seating force rather than an unseating force. The stability will be enhanced by increasing the height of the flanges to the maximum permitted. An esthetic effect, more nearly that of the finished denture, may be obtained by allowing the tissues to drape over the border of the record base as on the finished denture. The contour of the labial surface from the border to the incisal edge should follow the same general contour as the finished denture. This will permit a better survey of the stability that the finished denture will have.

C. *Be Sufficiently Rigid to Withstand Biting Forces.*—A record base that is not rigid can be distorted very easily during the recording of jaw relations.

D. *Be Dimensionally Stable.*—The material used should show only the minimal change from mouth temperature to room temperature. It should not change appreciably at room temperatures for the length of time required for constructing dentures. Dimensional changes in a record base make it nearly impossible to obtain and transfer accurate records to the articulator.

E. *Be So Constructed That It May Be Used as a Base for Setting Up the Teeth.*—The record bases should be constructed of a material that can be made thin enough to allow sufficient intermaxillary space for setting the teeth if it is so desired to use the baseplates for this purpose.

F. *Be Possible to Fabricate Inexpensively, Easily, and Quickly.*—The expense, both in money and time, of fabricating a record base should not be given the initial consideration, but nevertheless must be considered from both the dentist's and the patient's point of view. Metal bases probably would be the ideal for record bases and denture bases, but it is not economically possible to construct metal bases for every full denture patient.

G. *Have No Undesirable Color.*—This is one requirement that has been given very little attention. Brown gutta-percha baseplates have been commonly used upon which pink occlusion rims are built. Record bases of undesirable color can have a deleterious effect upon a new denture patient. A fastidious woman, who is receiving her first experience in complete denture fabrication, can very easily be so upset by the thought that the finished denture will resemble the unsightly record base that obtaining accurate maxillomandibular records might be almost impossible.

It probably would be better if the baseplate materials resembled the gingival tissues and the occlusion rims resembled tooth color.

The advantages of accurate record bases are: (1) Recording of correct maxillomandibular relations is easier. The patient will be relaxed because of comfortable and esthetically acceptable bases. Bases that are well adapted are not as likely to slip and slide on underlying tissues. (2) Record transfers are less likely to be in error. Accurately constructed record bases will fit the master cast the same as the mouth. Thus, records recorded in the mouth can be transferred to an articulator and the same relations as maintained in the mouth. (3) They give a clue as to the retention, stability, and support that the finished denture base will have.

Wright[11] stated, "Much time can be saved and disappointments avoided by testing the retention and stability of a proposed restoration before it is completed. This can be done most effectively by preparing a permanent denture base of vulcanite or metal which may be tried and tested in the mouth . . . ."

It is possible with some of the newer materials to make record bases easily and quickly that very closely approach the finished denture, and they need not be used as part of the finished denture.

The time saved later in the construction of the denture and the fewer adjustment periods that are necessary overshadow any disadvantages of using accurate record bases.

TYPES OF RECORD BASES

The many kinds of record bases can be divided into three types: (1) shellac gutta-percha baseplates, (2) metal baseplates, (3) plastic baseplates.

Shellac Gutta-Percha Baseplates.—Baseplates made of shellac gutta-percha have been used for years. Without modification, they meet only four of the seven requirements for an ideal record base: (1) They are dimensionally stable. (2) They are rigid if the edges are folded, and a wire is used for reinforcement.

(3) They can be fabricated inexpensively, easily, and quickly. (4) They can be constructed so that the bases may be used to set teeth on them.

Unmodified shellac gutta-percha baseplates: (1) Do not adapt to the basal seat area as the finished denture base, thereby making it difficult to transfer records accurately to the articulator from the mouth. (2) Do not have a color that will blend with the surrounding tissue. Even pink baseplates could be more esthetically desirable.

By modification, it is possible for shellac gutta-percha plates to meet the requirements of an ideal record base, except that by modification one important requirement is lost. That is—the expense and time used in fabrication is increased.

Modifications[12] that are necessary are: (1) A liner should be added of some stable material, such as zinc oxide-eugenol paste, plaster of Paris, artificial stone, modeling plastic (modeling compound), or cold cured acrylic resin. This liner can be placed with or without placing tin foil on the casts. The tin foil will come off the cast and become the tissue surface of the record base. The advantages of tin foil are: (a) to make a neater record base, and (b) to prevent the lining material from flaking away. There are some that feel that tin foil causes a decrease in retention and stability of the baseplate. (2) Wax should be added to the border and over the labial and buccal portion of the baseplate to the form of the finished denture. (3) The wax should be of an acceptable color for the gingival portion and tooth portion; then the record base becomes esthetically acceptable.

These three modifications will make the shellac gutta-percha baseplates meet the requirements for an ideal record base, except that they cannot be fabricated inexpensively, easily, and quickly.

Metal Baseplates.—Precious metal bases probably are as ideal record bases as it is possible to obtain, if the borders, flanges, and occlusion rims are covered with a wax of an acceptable color. Here again, the time and expense make these bases prohibitive unless they are to be used as part of the denture base, and the patient can afford this type of dentistry.

Low-fusing metal has been used for record bases and makes very fine bases if the same precise technique is employed that is used for precious metal casting. The color is objectionable, and the time consumed in fabricating these bases has kept them from gaining universal favor.

Plastic Baseplates.—Probably the first plastic baseplates were modeling plastic (modeling compound) lined with plaster of Paris or not lined. These are rather bulky for use for anything but recording maxillomandibular relations. Vulcanite baseplates have been used and are very satisfactory. They can be made to meet all the requirements for an ideal record base. With the wide use of the acrylic resins, it is becoming increasingly difficult to get vulcanite bases constructed.

With the advent of acrylic resins, a new field has been opened for record bases. As the cold cured acrylic resins have been improved, it has become apparent that they may be used for the construction of very fine bases. There are

two methods, with variations, for construction of cold cured acrylic record bases: (1) the pressure method, and (2) the sprinkle-on method.

The pressure method of constructing record bases as described by Harris[13] consists of:

1. Removing undercuts on the casts by wax or modeling clay.
2. Applying baseplate wax to the thickness and form desired.
3. Covering the wax with tin foil.
4. Making a modeling plastic impression of the cast over the wax and tin foil. The tin foil should come off in the impression.
5. Removing the wax from the casts.
6. Placing cold cured acrylic resin over the area where the wax was, and applying pressure to the acrylic resin by means of the impression until the acrylic resin is set. This method is time consuming.

Finger-formed bases are made by forming the doughy material over the areas it is desired to cover. The disadvantage of this method is that the acrylic resin is not accurately adapted and lacks uniform thickness.

The sprinkle-on method by McCracken[7] has proved very satisfactory in all respects. The technique as he describes it is as follows:

1. Relieve undercuts with wax or modeling clay.
2. Paint the cast with an alginate foil substitute. Tin foil does not work satisfactorily.
3. Wet one-third of the area of the cast with monomer.
4. Sprinkle enough polymer on the wet surface to absorb the liquid monomer.
5. Repeat this procedure three or four times, and then start another segment. Continue this until the tray is formed to the desired thickness.
6. Allow the tray to set for twenty to thirty minutes, remove, trim, and polish.

The accuracy with which anatomic detail may be reproduced and the strength and dimensional stability of extremely thin portions make the sprinkle-on method of using cold cured acrylic resin ideal for constructing record bases. All acrylic resin trays should be kept in water while not in use or there will be dimensional changes.

Recently, Harris[14] has described a technique for making record bases for patients with undercut ridges. He uses a fast-curing soft plastic to line oversized acrylic resin trays. This material is said to spring from undercut areas and resume its original shape.

There also are machines for molding heated plastic disks to casts to form record bases. The disadvantages of this method are: (1) It is not possible to form a peripheral roll. (2) A machine is required to press the disks into the desired shape. (3) There is the possibility of fracture of casts.

SUMMARY

1. It has been suggested that the term "stabilized baseplate" is not entirely correct. It was suggested that record base be used to designate the base upon which maxillary and mandibular records are recorded.

2. Seven requirements for ideal baseplates were presented.

3. The advantages and disadvantages of ideal record bases were presented.

4. The various methods and techniques for constructing record bases were discussed.

5. It was suggested that the sprinkle-on method of constructing record bases of acrylic resin is an ideal technique.

CONCLUSION

House[15] made the following statement in 1920:

"No single step in this work can properly be said to be of minor importance, but there are some which employ a greater relative danger of error than others. The subject of bite plates and their construction offers an opportunity for the exercise of the utmost skill and demands indeed the most intelligent understanding. A bite plate that is not properly reinforced and adapted cannot possibly perform its function. The materials employed should be the very best obtainable and the technic used the most exacting possible. And to this end a thorough knowledge of the oral cavity, and all its parts is absolutely essential. The needed accuracy simply cannot be realized unless the operator has a much better knowledge of dental anatomy than that ordinarily possessed."

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THE KILE DENTOGRAPH

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Hutchinson, Kans.

THE DENTOGRAPH differs from all other articulating instruments in that it is custom-built by and for each patient. It becomes a new, individualized, three-dimensional articulator for each patient. The condyles do not move in the glenoid fossae on flat planes, as one might assume from observing the orthodox articulators, but rather they move on three-dimensional curves. This instrument records these variations.

The Dentograph is, in reality, two instruments in one. It first records the lateral and protrusive jaw movements in three-dimensional form in a special tracing wax. Then these tracings are reproduced in stone, and the instrument is transformed into a tripod articulator. By employing these stone three-dimensional tracings as guides, the lateral and protrusive jaw movements are reproduced accurately in a similar manner to that employed in reproducing sound on a phonograph.

THE TECHNIQUE

The impression technique which I use was described in another article.[1] After the original impressions have been removed from the cast, they are used as bases for registering the lateral and protrusive jaw movements and for the arrangement of the teeth. In fact, these original impression bases are carried through to the flasking stage in the construction of the dentures.

Wax occlusion rims are built on these bases to approximate the vertical dimension (about 2 or 3 mm. short of the desired vertical dimension). The occlusal surfaces of the occlusion rims are channeled out, then slightly overfilled with a mixture of plaster and Carborundum powder (150 grit), as suggested by Paterson.[2]

THE CHEW-IN

The occlusion rims are placed in the mouth, and the patient is instructed to close on them firmly, then to move his jaw into all the positions of chewing. The plaster and Carborundum occlusal surfaces will wear each other down into the occlusal curve peculiar to the individual patient as shown in Fig. 1. This procedure must be continued until the vertical dimension is reduced to the desired functional height with an adequate free-way space.

When these measurements are satisfactorily established, the patient is instructed to close his back teeth. This action, due to the muscle fatigue developed

Read before the New Orleans Dental Conference, Nov. 13, 1951.
Received for publication Aug. 6, 1954.

during the chew-in, will provide a sufficiently accurate occlusal centric relation record for the purpose of mounting the tracing arches (Fig. 2, *1* and *2*). The true occlusal centric relation is ascertained later in the tracings. The patient is instructed to maintain this position firmly while the bases are stapled together.

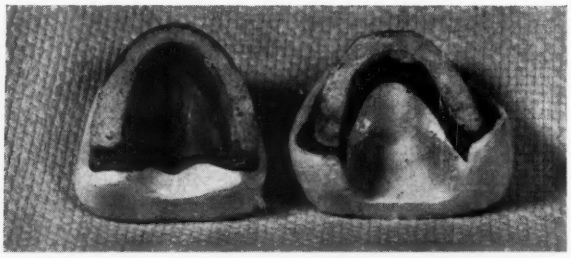


Fig. 1.—Carborundum and plaster filled occlusion rims chewed-in. The occlusion rims are built on the impressions which serve as bases.

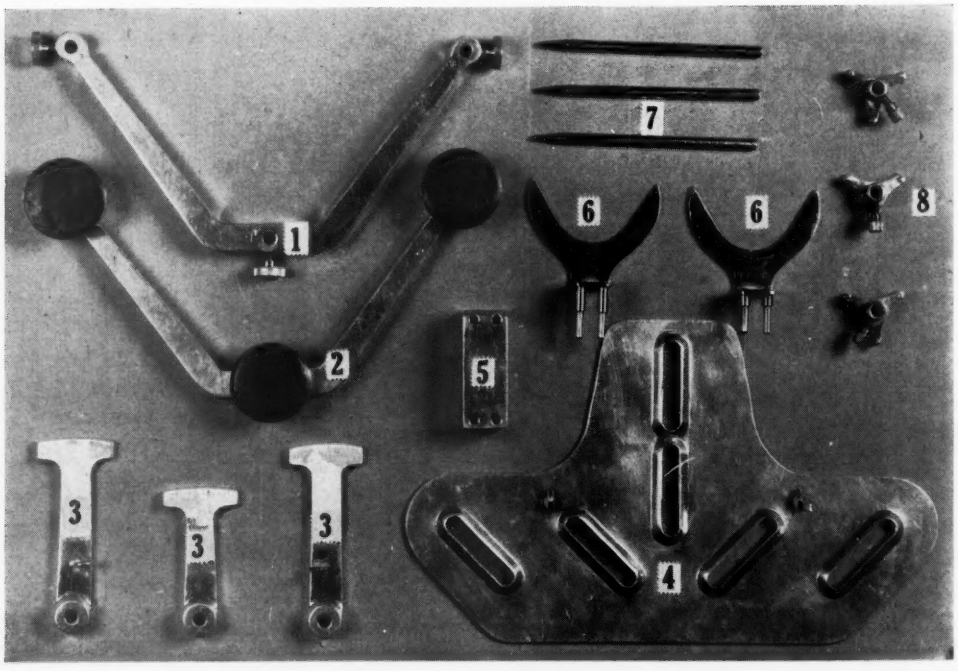


Fig. 2.—The Dentograph disassembled: *1*, Upper tracing arch; *2*, lower tracing arch; *3*, upper plaster arms; *4*, lower perforated plate; *5*, assembly jig; *6*, bite stems; *7*, tracing pins; *8*, centric tripods.

Then, after chilling, both upper and lower bases are removed from the mouth as a unit. The bite stems are held firmly in the assembly jig block (Fig. 3) while their points are heated in a flame and inserted into the occlusion rims which are maintained in centric position by staples (Fig. 4). When the wax has cooled, the assembly jig block is removed.

ASSEMBLING THE TRACING ARCHES

The casts are positioned in the bases to facilitate their handling while the upper and lower tracing arches (Fig. 2, *1* and *2*) are locked in position on the bite stem studs (Fig. 5). The occlusion rims remain stapled together in their original mouth position.

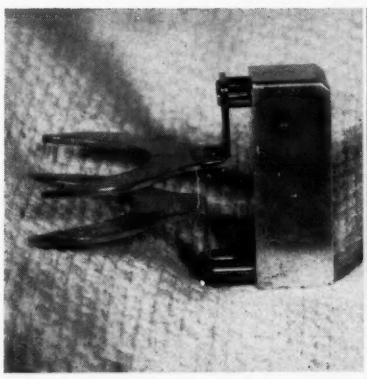


Fig. 3.

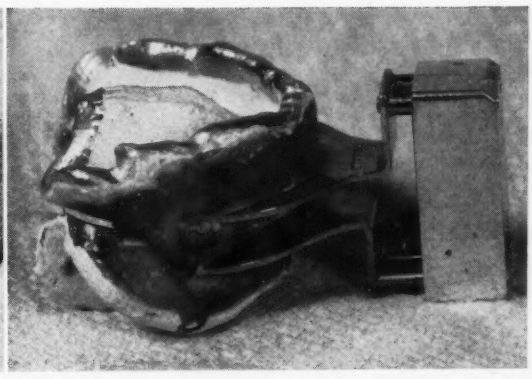


Fig. 4.

Fig. 3.—The assembly jig and the bite stems.

Fig. 4.—The chewed-in occlusion rims are held together by staples while the bite stems are attached with the aid of the assembly jig.

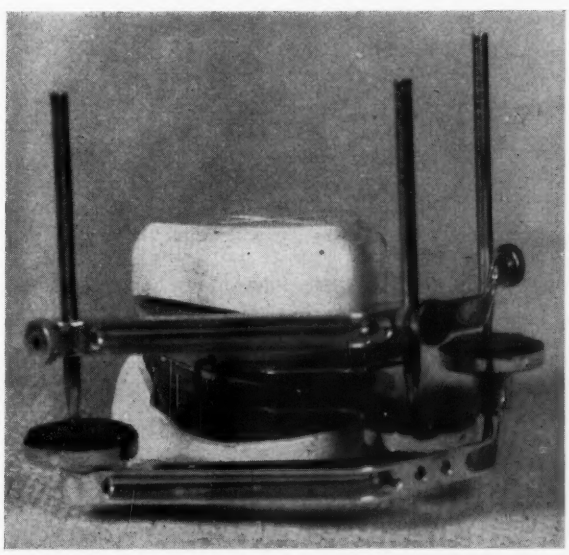


Fig. 5.—The tracing arches are attached to the bite stem studs and the tracing pins are adjusted to touch the center of the wax on the wax pans.

The lower tracing arch carries the tracing pans which hold the tracing wax (Fig. 6). The upper tracing arch is identical with the lower in dimensions, and it holds the tracing pins (Fig. 7) in parallel position as shown in Fig. 5. The

tracing pins have a flat-milled surface along one side for contact with flat-end set screws. This insures correct positioning in their respective hubs. This flat contact surface likewise prevents any rotation of the centric tripods (Fig. 2, *8*).

When the instrument is assembled, the points of the tracing pins on the upper arch should fall in the center of the tracing wax on the lower arch wax pans.

The staples holding the occlusion rims together are removed, and the tracing pins are removed to facilitate the placing of the assembly in the mouth. Then they are replaced (Fig. 8).

Fig. 6.

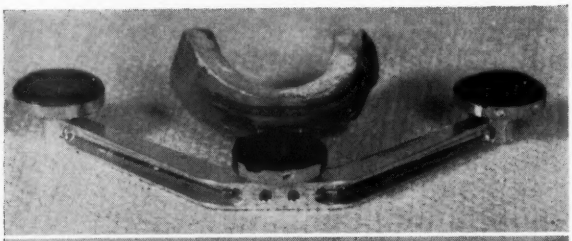


Fig. 7.

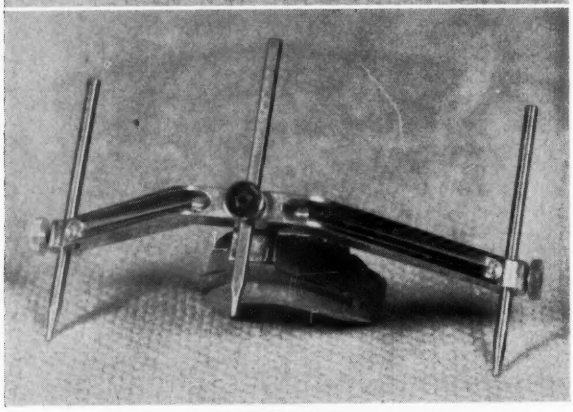


Fig. 6.—The lower tracing arch in position with wax in the wax pans ready for insertion into the mouth.

Fig. 7.—The upper tracing arch and tracing pins in position.

DEVELOPING THE TRACINGS

During the process of chewing-in the occlusion rims (Fig. 1) the muscles of mastication were the guiding factors. The temporomandibular joints were the limiting factors. The uneven occlusion rims with a slightly opened vertical dimension were the interfering factors. With the vertical dimension established and the occlusion rims back in the mouth (Fig. 8), the occlusion rims become the guiding factors with the muscles of mastication furnishing the motive power.

The patient is instructed to move his jaw slowly into a lateral position while he holds the occlusion rims firmly together. The tracing pins, having been lowered into contact with the tracing wax, carve a track into the tracing wax. After reaching the limit of lateral movement, the patient is instructed to open wide, then close his back teeth together. Thus, the jaw returns to its centric relation without difficulty or strain.

This procedure is repeated in right and left lateral and protrusive movements with the opening and closing action following each excursion. The tracing pins are adjusted to maintain a constant contact with the tracing wax until the tracings are carved to sufficient depth to make sure that the tracing pins will follow the reproduced grooves in the stone tracings.

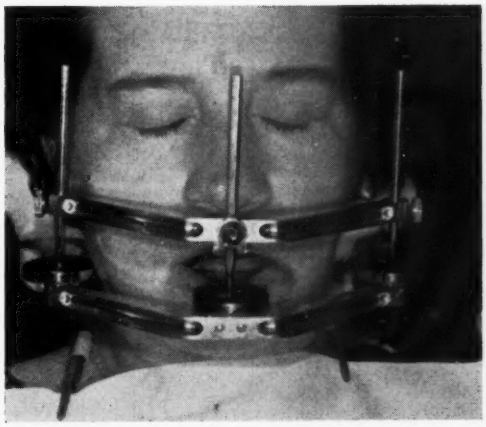


Fig. 8.—The occlusion rims in the mouth with the tracing arches attached and prepared for making the tracings.

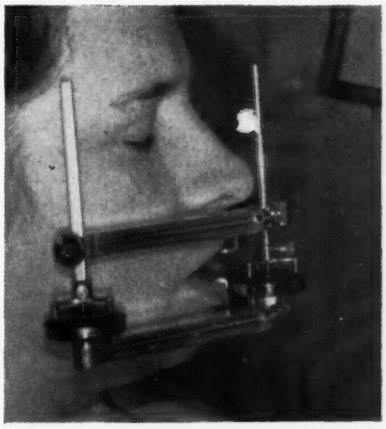


Fig. 9.—The centric tripods are in position. The tracing pins were raised to permit their attachment, then lowered into contact with the tracing. The centric tripods were forced gently into the tracing wax and locked in position.

Through the process of developing the tracings, a certain amount of muscle fatigue occurs, and the jaw automatically returns to the comfortable centric relation. This is evidenced by the tracing pins contacting the same centric dots made in the tracing wax after each opening and closing action. With the tracings completed and the jaw in the centric position, the occlusion rims are stapled together again in the mouth.

PLACING THE CENTER TRIPODS

The tracing pin set screws are released and the tracing pins are elevated sufficiently to permit placing the centric tripods (Fig. 2, *8*). The tracing pins are then lowered through the centric tripod hubs until they contact the tracings, and the tracing pin set screws in the upper arch are tightened. Then the centric tripods are pressed into the tracing wax until each leg of the tripod makes a shallow indentation in the wax. The tripod thumb screw must be properly aligned with the flat surface of the tracing pin. The thumb screw is then tightened securely (Fig. 9).*

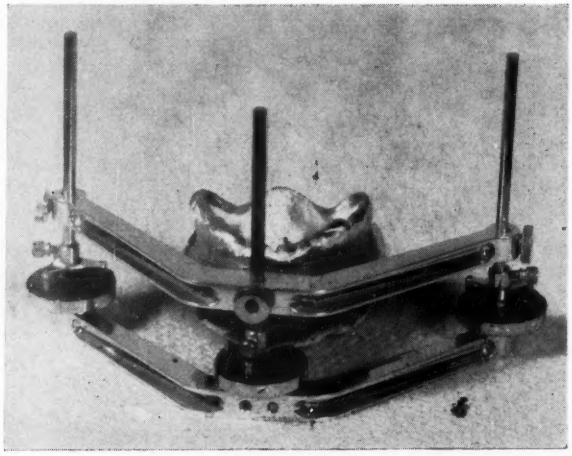


Fig. 10.—The Dentograph and bases removed from the mouth. The centric tripods are locked in position.

This procedure assures the correct positioning of the stone reproduction tracings when the mechanism is transformed into an articulating instrument. The bases and the assembled Dentograph are removed from the mouth as a unit (Fig. 10).

The thumb screw of each of the centric tripods is in different positional relation to the legs of the tripods in order to prevent interchanging the tripods (Fig. 2, *8*). The tripods are lettered R, L, and F for right, left, and front, for further distinction.

REPRODUCING THE TRACING IN STONE

While the occlusion rims remain stapled together, the tracing pins and centric tripods are released and raised free of the tracings. The lower tracing arch set screws are released, and the arch is removed from the bite stem (Fig. 11). Any frayed edges of the tracings are smoothed, and the letters R, L, and F are carved in the tracing wax. This is done for identification of the stone reproductions of the tracings. After the tracings are smoothed, they are brushed with a soft camel's-hair brush and mild soapsuds, and rinsed in cold water.

*Note: The centric tripods may be positioned in the laboratory with greater ease than in the patient's mouth.

A soft mix of plaster is then brushed into the tracings. Air bubbles in the plaster are avoided by vibrating the tracing arch. Plaster is built up several millimeters thick for bulk and strength (Fig. 12). The tracings may be boxed with adhesive tape or a wax strip to desired thickness of plaster. While the plaster is setting, the lower bite stem is heated and removed from the occlusion rim.

When plaster on the tracings has set thoroughly, it is separated from the tracings, and boxed with adhesive tape or a wax strip. A separating medium is applied to the plaster impression of the tracings and a heavy mix of stone is vibrated into these impressions.

Fig. 11.

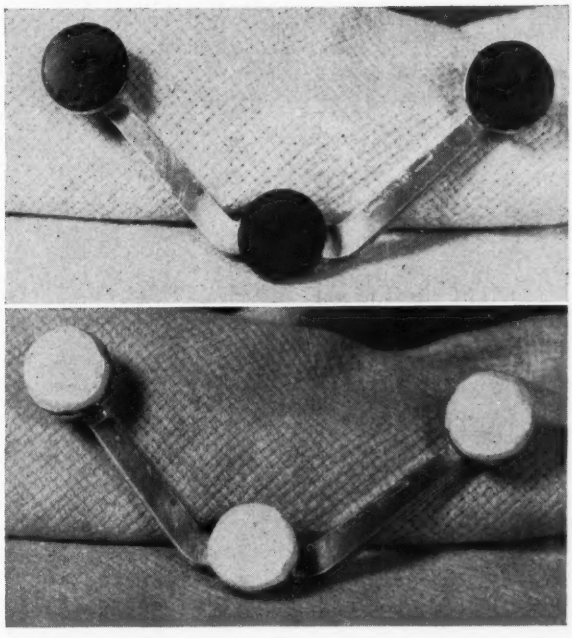


Fig. 12.

Fig. 11.—The lower tracing arch with the completed tracings and the indentations made by the centric tripods.
Fig. 12.—Plaster impressions of the tracings in wax.

BUILDING THE ARTICULATOR

When the stone tracing blocks are set thoroughly, they are separated from the plaster impressions. The stone tracing blocks are attached to their respective centric tripods and tracing pins by means of sticky wax at each tripod leg (Fig. 13). The casts should have keyways cut in their bases so they may be repositioned correctly on the instrument for the final grinding and balancing of the teeth after the dentures are cured.

A separating medium is applied to both master casts but *not* to the stone tracings. Suitable amounts of plaster are placed on the perforated base of the Dentograph, and the lower cast and stone tracing assembly is set in this plaster (Fig. 14). When the lower assembly plaster has set, a suitable amount of plaster is placed

Fig. 13.

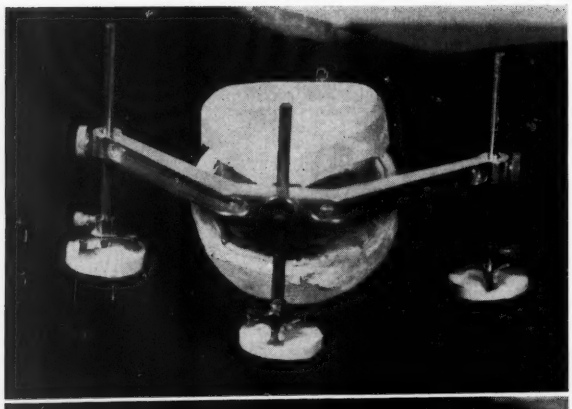


Fig. 14.

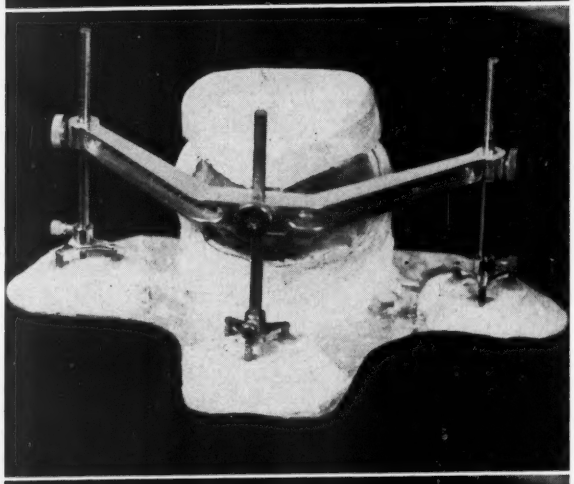


Fig. 15.

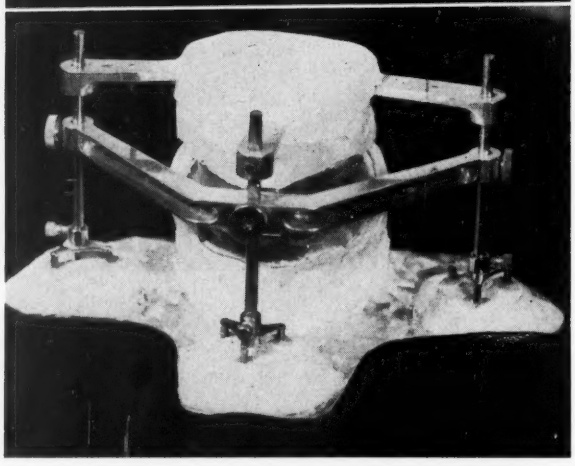


Fig. 13.—The stone tracing blocks are attached to the tripods with sticky wax. Note the grooves in the bases of the casts.

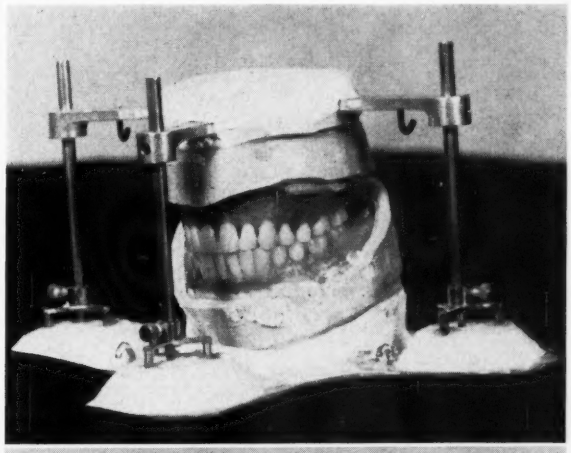
Fig. 14.—The lower cast and the stone tracing blocks are mounted in plaster on the lower perforated plate.

Fig. 15.—The upper cast is attached to the tracing pins by plaster and the upper plaster arms.

on the upper cast, and the upper plaster arms (Fig. 2, *3*) are positioned on their respective tracing pins. The calibration marks* on the tracing pins are equalized above the plaster arms. The plaster arms are covered with plaster to attach the upper cast to the tracing pins (Fig. 15).

When the plaster is thoroughly set, the tracing pins are released and removed. Then the upper tracing arch is released and removed from the upper bite stem, and the stem, in turn, is removed from the occlusion rim by heating.

Fig. 16.



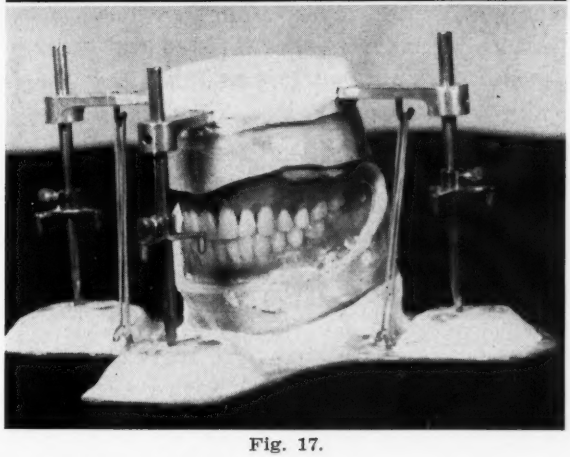


Fig. 17.

Fig. 16.—The teeth are arranged in centric occlusion.

Fig. 17.—Rubber bands are attached to assist in holding the tracing pins in the stone tracings while the occlusion is perfected by milling with Carborundum or pumice.

The tracing pins now are replaced and securely locked in both the plaster arms and the centric tripods. The occlusion rims are unstapled and the centric tripods are freed from the stone tracings. The upper assembly may now be lifted from the lower. The baseplates can be taken from the master casts and all can be reassembled.

*The calibration marks on the tracing pins are merely a precautionary measure providing a means whereby the tracing pins may be returned to their original length location, thus assuring positive rebalance of the mounting relations in case of accidental displacement.

SETTING UP THE TEETH

The teeth are set in the wax occlusion rim to occlude with the chewed-in occlusal surface of the opposing occlusion rim. Then the opposing teeth are set to occlude with these teeth, and all are arranged in centric occlusion (Fig. 16). After the teeth are set by this procedure, the trial dentures are placed in the mouth for esthetic approval.

BALANCING THE TEETH

The palatal portion of the upper base is sawed out as for relining a denture. Both upper and lower bases are replaced on the master casts. The Dentograph is closed (Fig. 16) and the bases are waxed securely to their respective casts. The tripods are now released and moved up on the tracing pins (Fig. 17). The upper or lower (usually the upper) part of the Dentograph may be moved now as a unit, with the tracing pins following the grooves in the stone tracings. The teeth can be repositioned or ground to balance the occlusion approximately. Then the final carving is completed.

It is advisable to place a separating medium on the casts again before investing them in the flasks to insure their easy removal after curing. Thus, they may be returned to the Dentograph intact for the final grinding of the teeth to perfect the balance of the occlusion.

Small hooks on the right and left plaster arms and on the perforated base are provided for attaching light rubber bands which serve as a third hand to hold the tracing pins in gentle contact with the stone tracings while the final fine grinding to balance the occlusion is completed with Carborundum or pumice (Fig. 17). Dry graphite is used as a lubricant in the stone tracings. Oil or grease should *not* be used.

CONCLUSION

In all other fields of restorative dentistry, a substitute is always possible, but, in the edentulous mouth, nothing can be substituted for dentures. They are the last resort. This is the place where care, study, and attention to detail are necessary, if the mouths of these crippled patients are to be restored to their deserved comfort, efficiency, and appearance.

This entire procedure is unorthodox and may seem weird and complicated, but, in practice, it is quite simple and will result in balance, comfort, and efficiency of dentures.

"Whatever is worth doing at all is worth doing well."

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DUPLICATION OF THE ESTHETICS OF AN EXISTING IMMEDIATE DENTURE

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IT IS GENERALLY agreed that the esthetics of an immediate denture produces one of dentistry's most flattering results from the patient's point of view. However, the patient should be advised, at the time of the pre-extraction discussions, about the need for subsequent dentures as physiologic changes develop.

The following procedure provides a psychologic appeal to the patient, inspiration to the prosthodontist, and confidence to the technician in accurately duplicating the esthetics and phonetics of the original denture. The patient is not without the original immediate denture for more than an hour. The procedure encourages the use of butted anterior teeth in the immediate denture without the usual alveolar trimming. This makes it possible for the labial flange to be omitted for transitional esthetic value and facilitates a more normal resorption. There are exceptions wherein the alveolar collar is reduced and a short, thin labial flange is used; but ordinarily the mere rounding and smoothing of the ridge lap are sufficient. The lip conformation is supported more naturally by the labial curvature of the denture teeth. The anteroposterior position of the original anterior dentition is maintained; stock porcelain or plastic teeth may be employed. The laboratory procedure of this technique is basically the same as that used for duplicating the esthetics in the original immediate denture.

THE ORIGINAL DENTURE

The denture for immediate insertion is made in the usual way except that no provision is made for extensive alveolectomy, and the labial flange is omitted (Fig. 1). The anterior teeth are inserted well into the sockets even if septal bone is to be removed. The irregular characteristics of the original teeth are retained but with artistic improvement. A photograph of the patient which shows the natural teeth in a smile is of value, no matter how candid the shot or of what age the picture. The existing diseased, malposed, or periodontally involved teeth may be altered. The restoration of the original youthful appearance is appealing to close friends and relatives of the patient who knew her before her teeth deteriorated. The shade of the teeth is improved toward the lighter yellow saturations in direct proportion to the resulting natural irregularity. Diseased teeth requiring removal rarely should be duplicated in color saturation in the immediate denture if the patient is to be flattered. To paraphrase, "In denture work, so often beauty does as beauty is." Practically, patients who are flattered esthetically and artistically with their denture appearance seem to have fewer troubles in every way than those that feel their "dentures do nothing for them."

Psychologically, age has little to do with this reaction. No one is against looking his best.

Presented as a clinic at the meeting of the American Denture Society, Cleveland, Ohio, Sept. 26, 1953.

Received for publication Jan. 14, 1954. Revised by the author Oct. 20, 1954.

The depth of insertion of the denture teeth into the sockets is varied according to the reason for the removal of the teeth. The treatment required when the teeth are lost because of periodontal disease is different from that when they are lost because of caries. Allowance may have to be made for scalloping the labial

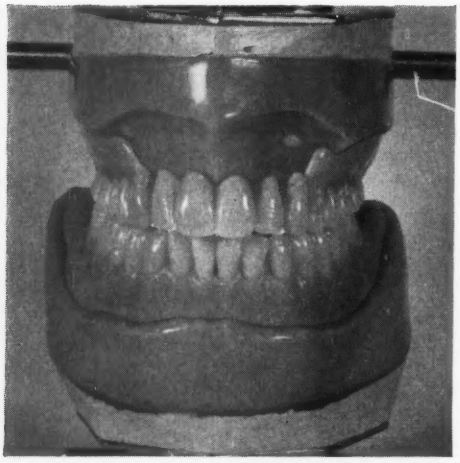

Fig. 1.—The immediate denture as it was made originally. A thin short labial flange might have been used.

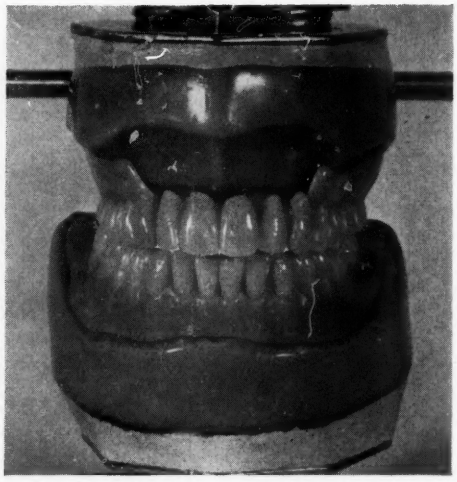

Fig. 2.—Alveolar resorption has taken place superiorly and posteriorly to produce this typical appearance.

alveolar crest surgically for better tooth position. It may be necessary to remove the alveolar crest surgically on account of a high lip line, if an excessive length of vertical overlap existed in the original dentition, and if an increased vertical dimension would not allow sufficient free-way space. The patient facing this procedure of the labial flangeless immediate denture must be prepared in advance for the wonders of karaya gum.

In due time the alveolar resorption will progress superiorly and palatally, leaving the butted anterior teeth without tissue contact but in their original lip supporting position (Fig. 2).

DUPLICATION OF THE IMMEDIATE DENTURE

The procedure of duplication of this denture by replacing it with a new one which will leave the original one available for use and later reconstructing the first denture as a spare is the consideration of value to the patient.

The loss of vertical dimension by alveolar resorption throughout the basal support is evaluated. A low-fusing, soft sheet wax, equivalent to Kerr's Tissue Seal Wax, is placed over the palatal portion of the denture, and the denture is seated into occlusion. This is repeated until the denture is in its original vertical position. A strip of wax is added over the post dam area to perfect the seal (Fig. 3). Strips of the same wax are adapted over the buccal flanges of the denture. The wax is thoroughly softened in water at 130° F., and the borders are carefully muscle molded (Fig. 4). This is repeated until full buccal borders have been developed. The impression of the internal surface is completed with

a zinc oxide and eugenol cement. The usual impression procedure for relining a lower denture is now carried out.

Several layers of a firm baseplate wax, thoroughly softened and covering most of the anterior teeth, are used for making an arbitrary checkbite (Fig. 5). This is chilled and removed from the mouth. Plaster of Paris in a plaster syringe is used

Fig. 3.

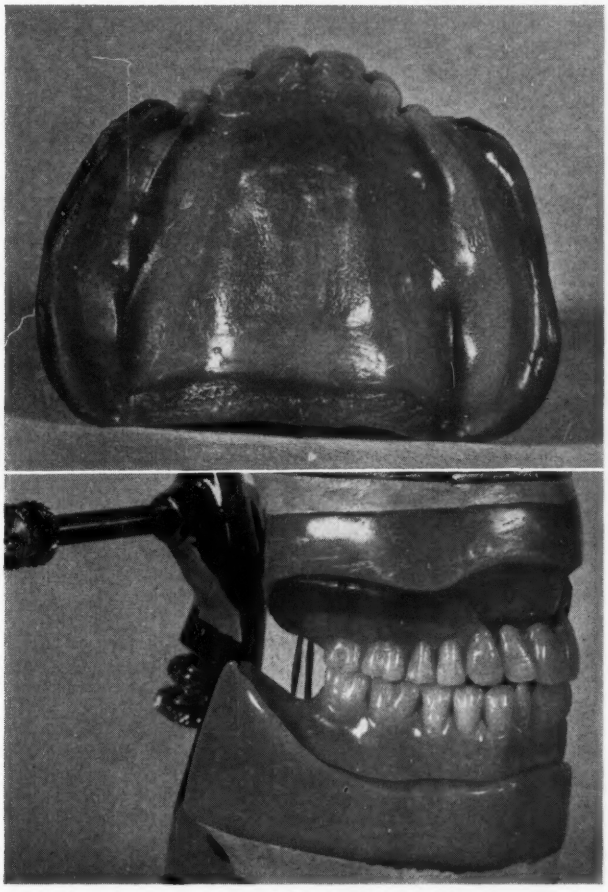

Fig. 4.

Fig. 3.—The loss of vertical lip line length is re-established by using soft wax on the impression surface of the denture. The post dam is built to compensate for tissue loss.

Fig. 4.—The buccal borders are developed in soft wax.

to complete the impression of the labial side of the upper ridge in order to determine the shape of the labial flange (Fig. 6).

The patient is asked to wait while the laboratory procedures are accomplished. Stone casts are made from the boxed impressions. When the stone, to which was added a little terra alba, has set, the teeth are cleaned; and alginate impressions are made of the denture teeth. Stone casts of the teeth are made in this impression. It is well to include a very thin stone duplicate of the existing rugae area for phonetic reasons. The dentures are oriented in the wax checkbite, without separating them from their casts, and mounted on an articulator. The upper denture is removed from the cast; the wax checkbite remains in position on the lower

denture. The stone teeth are now removed from the alginate impressions and trimmed to their coronal outlines. This is done on the anterior teeth only since the posterior teeth have no esthetic value at this time, except perhaps the upper first bicuspids. The six upper stone teeth are placed in the wax checkbite. A

Fig. 5.

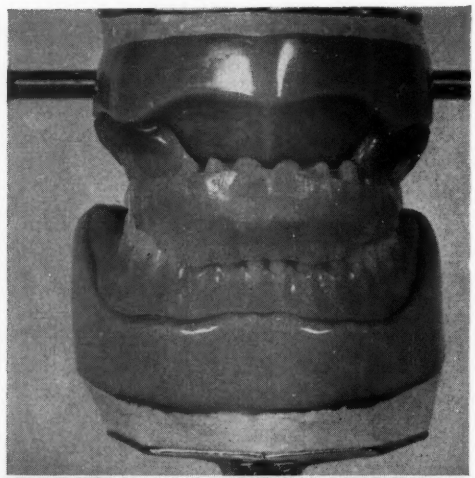

Fig. 6.

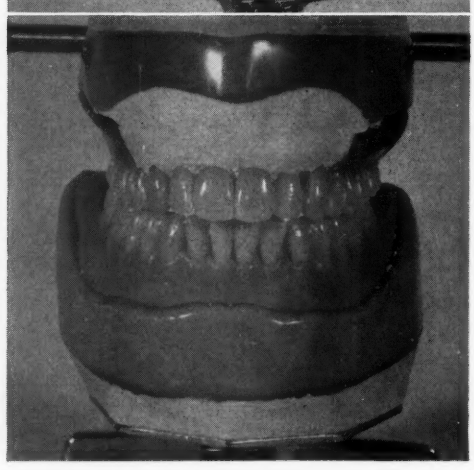

Fig. 5.—An arbitrary wax checkbite covers the anterior teeth. The overflow of the zinc oxide and eugenol internal impression is not shown.

Fig. 6.—The completed labial flange impression in plaster of Paris.

wax baseplate is adapted over the upper cast, and the articulator is closed. The stone teeth are luted to the upper baseplate (Fig. 7). The procedure may then be repeated for the six lower anterior teeth. The immediate dentures are cleaned and returned to the waiting patient.

The wax baseplates with the stone teeth attached to them are removed and set aside. Shellac baseplates are adapted and stabilized with autocuring resin. The vertical opening, free-way space, centric relation, and articulator mounting

records are made in the usual manner (Fig. 8). The important esthetic record of the shape, form, and position of the original teeth is preserved by the stone teeth on the wax base, regardless of any remounting to correct the centric relation

Fig. 7.

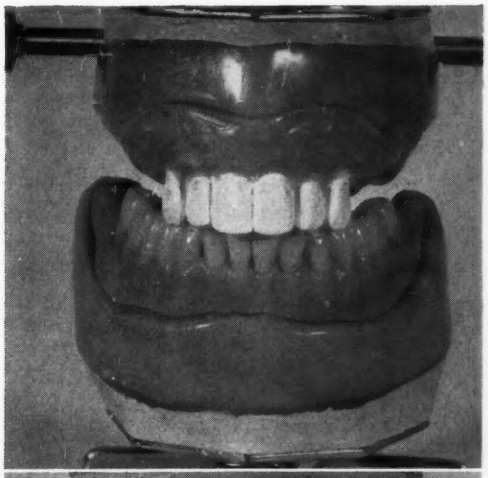

Fig. 8.

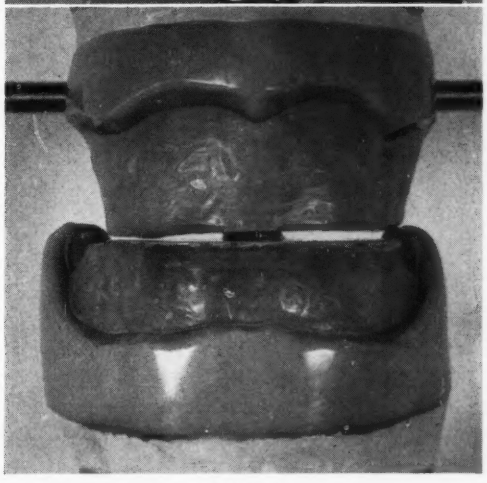

Fig. 7.—The stone teeth are luted to the wax baseplates on the master cast as guided by the mounted checkbite which maintains them in the same position as the original teeth.

Fig. 8.—Stabilized baseplates in position on the master casts are prepared for new intraoral records and remounting.

record. The record of the tooth mold was saved from the original immediate denture. Any alteration of the original teeth by grinding is obvious in the stone teeth, which are removed from the wax base, one at a time, and replaced in the same manner as that used when the immediate denture was made.

A thin labial acrylic flange with a tinted, mottled, and carved veneer is added to the denture as required for labial support. However, it is the position and curvature of the labial arch of teeth that supports the lip and not the flange (Fig. 9). The original immediate denture may be rebuilt at a convenient time after

the new denture is completed. The procedure influences the patient to accept the original denture as a spare, since he is assured of the perpetuation of his appearance.

DUPLICATION OF COMPLETE DENTURES

The technique is easily adapted to the duplication of the esthetics of a full-flanged denture when a second one is to be made. Also, the procedure can be used when the ordinary relining impression procedures are not adequate. In these cases, it is desirable to develop a cast from primary and secondary impressions and to ignore the existing denture as a tray.

Fig. 9.—The completed duplicate dentures with the anterior teeth in the same positions as in the original denture and with a similar lingual form for phonetics.

The internal surface of the full-flanged denture is relieved of undercuts with modeling clay, and a cast is made of plaster. The dentures are mounted on the articulator using a wax checkbite. The palatal and ridge surfaces of the upper plaster cast will provide a sufficient seat for the wax baseplate, which has the stone teeth attached. The baseplate is transferred to the master cast later when the new articulator mountings are complete. The new artificial teeth are then substituted in the same way as in duplicating an immediate denture. The procedure does not prevent the substitution of newer and improved molds and shades of teeth. The value lies in the arch form, lip-supporting quality, and tongue familiarity which will remain basically the same.

Another use of the technique is in duplicating a satisfactory, well-fitted full denture. An impression of the internal surface of the denture, including the buccal and labial borders is made with a hydrocolloid impression material in a tray. The denture is carefully removed, and the resultant impression is covered with impression plaster. This negative form is poured in stone to make the master cast. The teeth of the denture are duplicated in stone in an alginate impression which includes the lingual and palatal surfaces of the denture. A very thin layer of stone is painted onto the rugae and palatal surfaces to maintain their form. Phonetics are maintained by the duplication of the tooth position and lingual and palatal surfaces in the duplicate denture.

Fig. 10.—A patient psychologically conditioned to accept physiologic changes with duplicate dentures.

CONCLUSION

Relining and secondary denture procedures are often delayed too long. The patient who is influenced into the quick transition from natural teeth to an immediate denture, and, a few months later, is told to hide in a closet for two or three days while the immediate dentures undergo reconstruction, may become disillusioned. Therefore, duplication of the esthetics of any existing denture may be accomplished with confidence. The "free hand" method of tooth positioning is eliminated. The psychologic burden on the prosthodontist and the patient is eliminated by the accuracy of the procedure. The goals of perpetuation of the esthetic effect and the production of a "spare" are achieved. The value of frequent duplication, pro re nata, of existing dentures, is illustrated (Fig. 10) by a typical patient for this service.

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COMPLETE DENTURE PROSTHESIS FOR A CASE OF ACROMEGALY*

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ALTHOUGH ALL OF US are familiar with the condition of acromegaly, very little has appeared in the dental literature concerning it. There may be found in the literature several references to acromegaly as a disease entity and to the possibility of restoring the existing dentition. To my knowledge there has been no recording of the prosthesis for an edentulous acromegalic.

This clinical entity is debilitating and often painful. An attempt to alleviate some of the oral manifestations of this condition can be gratifying to both the patient and the dentist.

The purpose of this essay, therefore, is to present the case history and the treatment plan for an edentulous acromegalic.

ACROMEGALY

Cause and Occurrence.—Postadolescent hyperplasia or tumor of the pituitary gland is usually given as the cause of acromegaly.[1] Cushing[2] believes it to be an oversecretion, normal or pathologic, of the pars anterior. It occurs most often in males between the ages of 20 and 40 years.[3]

Morbid Pathology.—There is a hypertrophy of bony structures with an increase in size of adjoining soft tissues. The periosteum thickens and forms deposits of new bone. These new bone deposits are laid down near the epiphysis and may be irregular. The disease most often affects the bones of the face, skull, fingers, and feet. The kidney, liver, and spleen may enlarge. The sella turcica increases in size and protrudes into the cranial cavity.[4]

If the cause is due to simple hyperplasia of the pituitary gland, there may be quiescent periods, or the process may be permanently checked.[3] Death is due to cachexia, cardiac asystole, or increased intercranial pressure.[5]

Signs and Symptoms.—Headache is a constant symptom. The angle of the jaw becomes obtuse. The ramus elongates and increases in size and density. There is hypertrophy of the coronoid and condyloid processes.[6] The lips become prominent and thick, and the nose increases in length and thickness. The tongue becomes markedly large, and the teeth become noticeably separated. Gradually the hands and feet approach great size, and the fingers have a spadelike appearance. Kyphosis is usually present. The face appears oval-shaped with prominent

*This essay won the first prize of $500 in the Prosthetic Essay Contest for senior dental students sponsored by The American Denture Society in 1953-54.

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supraorbital ridges and malar bones[4] (See Figs. 1, 2, and 7). Diagnosis is made by physical findings and the increase in the size of the sella turcica as noted in roentgenograms.

HOSPITAL CASE HISTORY

A white, 50-year-old man was first seen in a hospital outpatient department in 1938. He complained of constipation and flatus of three years' duration. He also complained of palpitation on exertion and tinnitus in his left ear. His mandible was enlarged and protruding. Oral examination revealed "six teeth plus a

Fig. 1.

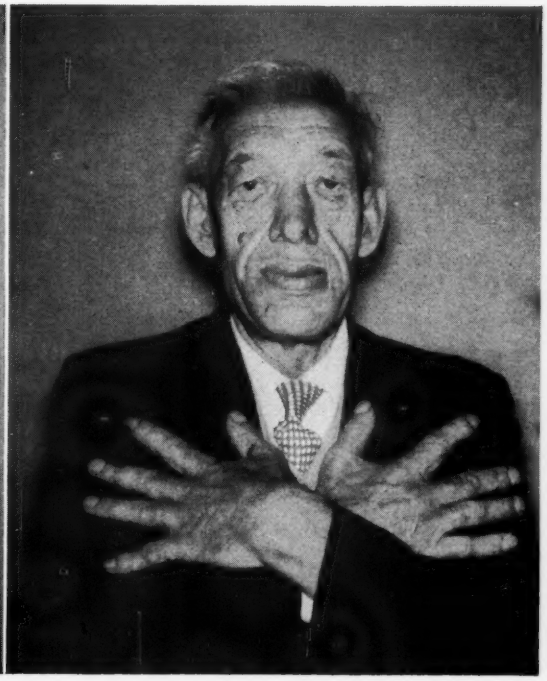


Fig. 2.

Figs. 1 and 2.—The patient before seating of the dentures.

bridge of four" which were in need of repair. Roentgenographic findings revealed a normal-sized sella turcica and dorsum sella turcica. Gastroscopic examination revealed an unusual rugal pattern but no pathology. The teeth were removed.

In 1940, physical examination revealed cardiomegaly and basal râles. The electrocardiogram revealed premature beats and auricular extra systoles. Symptoms of palpitation and flatus persisted and the patient complained of frontal headaches and edema. Roentgenographic examination revealed calcification of valves (aortic), cardiac enlargement (left ventricle), herniation of the cardiac end of stomach through the esophageal hiatus of diaphragm, and hypertrophic gastritis. The patient was digitalized.

In 1944, symptoms of dyspnea on exertion appeared.

A summary of diagnoses to 1946 included: acromegaly, hypertensive arteriosclerotic heart diesase, cardiac failure, auricular tachycardia, diaphragmatic hernia, pulmonary emphysema, hypertrophic gastritis (chronic), calcareous aortic valve.

In 1947, a thinning of the bone of the sella turcica was noted. Visual fields suggested bitemporal hemianopsia. There was no additional change noted in the size of hands, feet, and jaw. The headaches continued.

In 1948, the patient underwent hemorrhoidectomy and bilateral hydrocelectomy.

In 1953, the patient became deaf, and a diagnosis of bilateral otitis media was made. Because of the abnormal size of his tongue, his speech could not be understood. Since there was no change in the skull film since 1947, and the mouth structure had not changed, the patient was advised to secure dentures.

Fig. 3.

Fig. 4.

Figs. 3 and 4.—The patient wearing the dentures.

CLINICAL EXAMINATION

The conditions revealed by oral examination were classified into three groups: (1) conditions which were neither favorable nor unfavorable, (2) favorable conditions, and (3) unfavorable conditions.

Conditions Which Were Neither Favorable Nor Unfavorable.—The alveolar ridge form presented contours with mild difficulties for the efficient adaptation of dentures. The ridges required no surgical intervention. The vault form was of the arched type. The peripheral border attachments were from 6 to 12 mm. from the crest of the ridge.

Favorable Conditions.—The condition of the mucosa presented a normal uniform density of the membrane over the supporting area. The saliva was normal in consistency and amount. The maxillary and mandibular ridges were large, thereby offering the best opportunity for retention and stability. The upper throat form was extensive, with 12 mm. of immovable tissue beyond the hard palate.

The lateral throat form presented no dislodgment of a palpating finger by the palatoglossus and superior constrictor muscles.

Unfavorable Conditions.—The muscle tone was subnormal. The upper lip was exceedingly long, and the lips rolled out (See Figs. 1 and 2). The mandibular ridge was anterior to the maxillary ridge and lateral to it. The entire residual ridge of the mandible was larger than that of the maxilla. Ridge parallelism

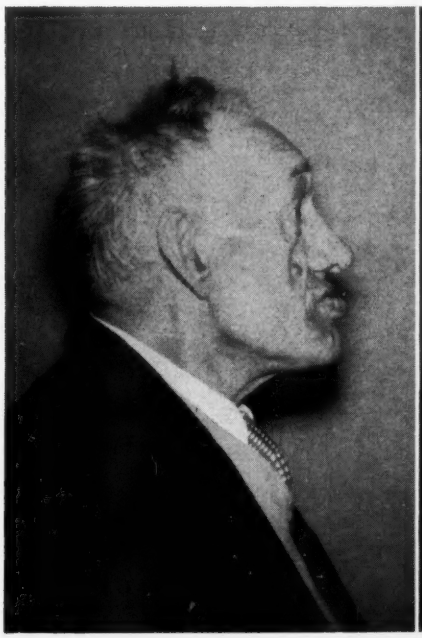


Fig. 5.

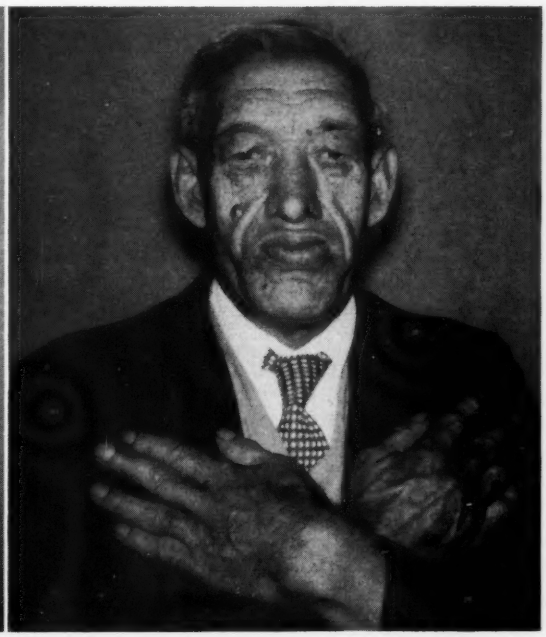


Fig. 6.

Figs. 5 and 6.—Profile and front views illustrating patient's attempted reduction of intermaxillary space.

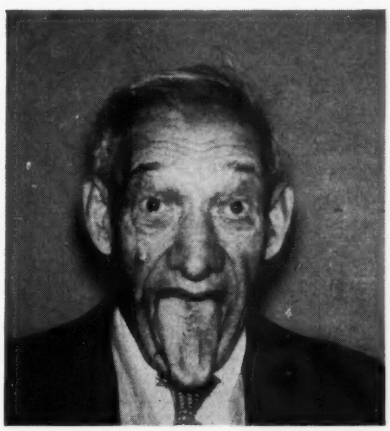


Fig. 7.—Size of tongue.

did not exist since both ridges were divergent anteriorly. The intermaxillary space was excessive (see Figs. 8 and 10). The muscle attachments, labial and buccal frenula, were attached close to the crest of the ridge.

The tongue form and position were abnormal. It not only had width posteriorly, which is commonly seen in patients edentulous for a long period, but the tongue also had great bulk and length as a manifestation of acromegaly (Fig. 7). In attempted closure by the patient, the mandible did not reach the maxilla and was lateral and anterior to the maxilla (Figs. 5 and 6). Since no mastication could be accomplished by the ridges, the patient had masticated solid foods for fifteen years by using his tongue against the palate. Consequently, the patient had an extremely active and strong tongue.

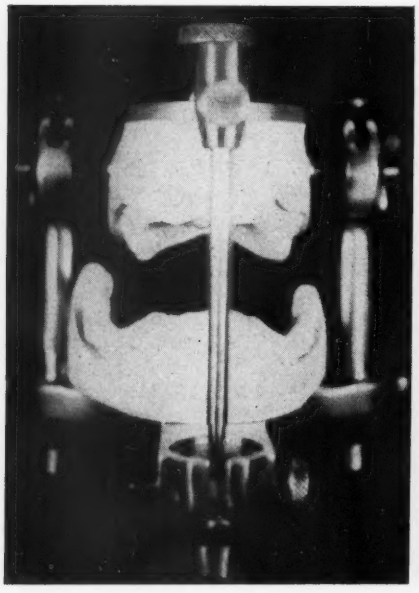


Fig. 8.—The casts mounted on the articulator.

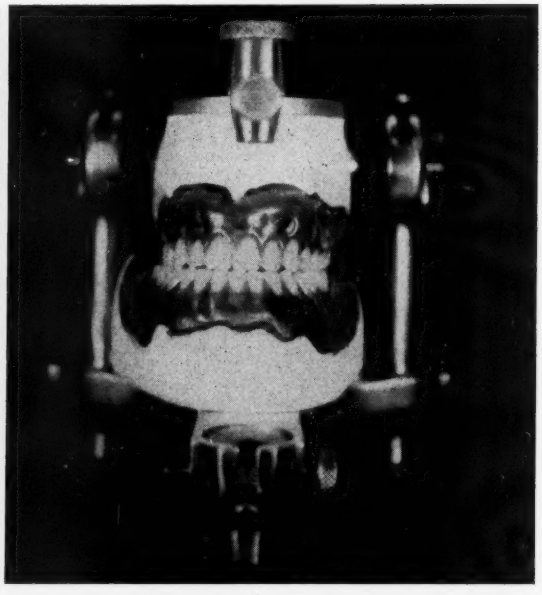


Fig. 9.—The wax setup mounted on the articulator.

The mental attitude of the patient was of the exacting type. Although suffering extreme ill health and lacking patience and determination, he was seriously concerned about the appearance and efficiency of the dentures.

Other undesirable factors were the patient's hearing loss and his inability to understand or speak the English language well.

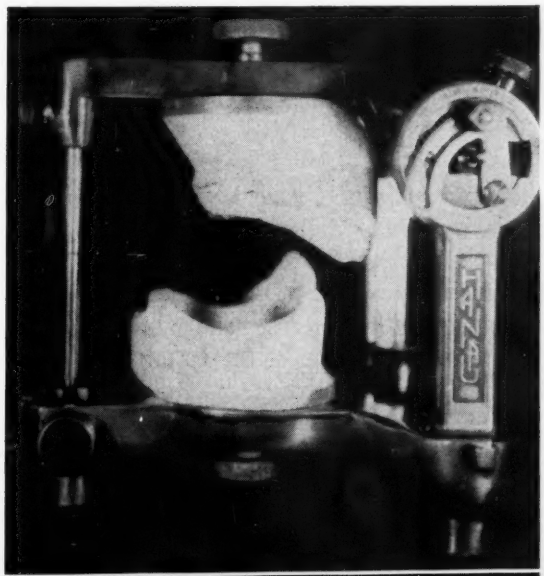
PROSTHETIC PROCEDURE

Impressions.—Primary impressions in stock trays were made using black compound for the maxilla and alginate for the mandible. Casts were poured. Trays for final impressions were made by adapting a thermoplastic type of tray material to the casts. The trays were trimmed 2 to 3 mm. short of the peripheral border. In the mouth, the trays were completely muscle trimmed with low-fusing

modeling compound. Excess modeling compound, not included in the periphery, was removed. Several small holes, the size of a 557 bur, were drilled in each tray. The final impression was made with a zinc oxide eugenol paste. Casts were poured and appropriately relieved.

Registrations.—Occlusion rims were adapted to the casts and adjusted to the mouth.

Fig. 10.



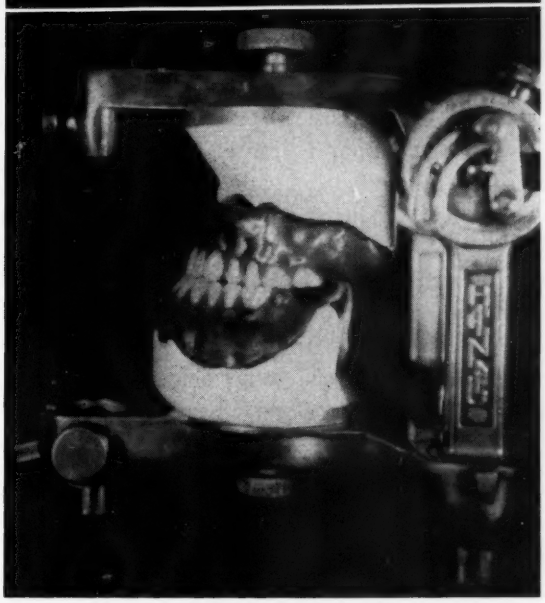


Fig. 11.

Fig. 10.—The casts mounted on the articulator.
Fig. 11.—The wax setup mounted on the articulator.

Rest position vertical dimension was established with the aid of the "M" sound. The maxillary cast was mounted on the articulator with a face-bow transfer.

The registration of centric relation could not be achieved with an arrow-point tracing because the size of the tongue would not allow sufficient space for the bearing plates. The muscles of mastication were fatigued by having the patient perform many opening and closing movements of the mandible. The patient was then instructed to close into the soft wax mandibular occlusion rim. This record of centric jaw relation was employed to mount the mandibular cast on the articulator (Fig. 8).

The condylar guidances were set at zero since the patient was unable to furnish a protrusive registration.

Tooth Selection and Setup.—Anterior teeth were selected for the patient. The length of the central incisor coincided with the high lip line measurement on the maxillary occlusion rim. The width of the anterior six teeth on a curve coincided with the measurement from one corner of the mouth to the other on the occlusion rim. The maxillary posterior teeth were selected with a crown-wise length complimentary to the anteriors and with their combined length equalling the measurement from the corner of the mouth to the anterior aspect of the tuberosity on the occlusion rim. Because of the zero degree condylar inclination, nonanatomic teeth were selected.

Using the labial aspect of the occlusion rims as an esthetic guide, the upper six anterior teeth were set up so that their incisal edges approximated the labio-incisal curve of the lower occlusion rim (Fig. 9). This resulted in the incisal edges being 13 mm. anterior to the crest of the ridge (Figs. 10 and 11). The upper posterior teeth were set up striving for function. Because of the extreme off-ridge arrangement of the anterior teeth, the ideal relationship of "tooth directly under the ridge" could not be achieved except for the second bicuspid and first molar. In setting up the lower anterior teeth, two extra central incisors were employed to give the correct upper to lower cuspid relationship (Fig. 9). The four central incisors were inclined lingually to an end-to-end relationship with the upper teeth (Fig. 11). The lower posteriors were set directly over the ridge, which resulted in a bilateral "cross-bite" relationship (Fig. 9). Because of the lack of space between the first molars and the anterior aspect of the retromolar pads, the second molars were omitted from the setup, and "half-molars" were waxed in their place. This resulted in the nonfunctioning of the maxillary second molars which were removed from the setup before the dentures were processed.

The upper denture was plumped very heavily in the anterior region, especially over the canine eminences (See Figs. 9 and 11).

The teeth were tried in the mouth. Centric relation and lateral excursions were checked. The effect of the plumping was carefully studied and altered to give an esthetic lip support (Figs. 1 and 3) and to reduce the depth of the nasolabial sulci (Figs. 2 and 4).

Processing and Adjustment to Mouth.—The dentures were carefully processed. They were inserted, and the occlusion was adjusted. The patient was instructed to incise food at the corners of the mouth and to masticate on the posterior teeth.

The patient is examined every six months. At the first examination all relationships were unchanged, and the patient reported his ability to incise food with the anterior teeth as well as to masticate with the posterior teeth.

In the event of an exacerbation of the medical picture, the six month re-examination appointment would disclose it. The patient would complain of a "tightening" of the lower denture. At this time, the need for readjustment or reconstruction of the dentures would be decided.

SUMMARY AND CONCLUSIONS

1. Full-denture prosthesis for the acromegalic is a field deserving attention.
2. The debility and complex ramifications of the disease make necessary an efficient masticatory apparatus.
3. Although, clinically, the unfavorable conditions outnumber the favorable conditions, dentures can be made for an acromegalic.
4. The prosthetic procedure differs from the average case mainly in the setting of the teeth and the plumping of the dentures.
5. An acromegalic can derive the benefits of both esthetics and function from full-denture prosthesis.
6. A six-month recall system would detect an exacerbation of the condition and determine the need for readjustment or reconstruction of the dentures.

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FREE-WAY SPACE*

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THE MEASUREMENT of the free-way space is a readily accessible factor and yet one that is subject to a great deal of controversy. At present, old dogma is being questioned and re-evaluated with the advent of newer and more accurate methods of measurement, such as cephalometric roentgenograms.

The free-way space has been a salient factor in the determination of two of the most perplexing problems in prosthetic dentistry, namely, the vertical dimension and centric occlusion. In this treatise, most of the material has been directed toward the measurement of vertical dimension, not because it is of more importance, but because determining the correct horizontal relation depends on measuring the correct vertical relation.[1] Numerous investigators have tried, unsuccessfully, to develop an exacting technique, either mechanically or physiologically or using a combination of the two, whereby the accurate vertical dimension and, hence, free-way space, of an edentulous patient could be measured. These men have arrived at a variety of clinical methods to help solve this difficulty, but none will give the absolute measurement. True, some claim that the exact measurements can be made via roentgenograms[2-8] and phonetics[9] prior to tooth extraction, but this is not the real problem. The difficulty arises with the edentulous patient or the partially edentulous patient who has no teeth in antagonism by which measurements can be made. However, all investigators agree or seem to agree that the crux of the problem lies in determining the rest position of the mandible and then allowing the proper amount of free-way space by which the mandible can move into centric occlusion during mastication and deglutition.

ANATOMY AND PHYSIOLOGY

Some investigators believe that the rest position of the mandible remains constant throughout life,[2-5, 10-12] and it has been noted as early as three months postnatally by Thompson.[4, 5] The rest position is believed to be the result of a complex muscular equilibrium plus gravity. The length, origin, and insertion of these muscles remain constant; only their tonicity may vary. When the tonus of the muscles of mastication, which pull the mandible from above, is in equilibrium with the tonus of the hyoid musculature, which pull the mandible from below, plus gravity, then the mandible is theoretically at "rest" because the tensions balance each other.

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*This essay won the second prize of $300.00 in the Prosthetic Essay Contest for senior dental students sponsored by the American Denture Society in 1953-54.

**Senior student at Tufts College Dental School at the time this essay was written (graduated in June, 1954).

In the act of closing, when the mandible moves through the free-way space to centric occlusion, the masseter and internal pterygoid muscles close the mandible up and supply the major crushing force.[13] The temporal muscle does not supply any great force until the teeth are at "centric."[13]

According to Boos,[10,11] each patient has a vertical dimension where a maximum biting force exists, and the muscles at the rest position are at "normal length, not stretched or sagged, for maximum power." He found that this maximum muscular force exists when there is a free-way space of 1 to 2 mm. at the posterior teeth. The free-way space is a normal entity and provides a relief from the muscle tension that occurs when the teeth go into occlusion. Therefore, Boos believes that a free-way space must be maintained so that forces will not act on the occlusion continually. Boos states that, if too little or no free-way space exists, the teeth are under great tension because the muscles cannot come to their normal length, and they are trying to find the maximum biting area. Boos also claims that, with too much free-way space, very little force can be exerted as the muscles are sagged and lose their power rapidly because they contract beyond their normal occlusal level, and masticatory efficiency is reduced. Niswonger[2, 3] found that, where less than the average free-way space existed, the patients hammered at their restorations or ridges with their dentures causing alveolar tissue changes until compensation took place and a comfortable free-way space was obtained.

Leof,[14] contrary to former opinion, states, "physiological manifestations are not constant but have a range, and they change with health, disease, emotional states, and age." He uses the human posture and development of various muscles as an analogy. As a particular muscle can be developed to overfunction via exercise, so can the masticatory muscles. Leof claims that the rest position of the mandible is controlled by muscle tone and not muscle length and, therefore, is not constant throughout life but is constant for any particular individual at any period of his life. His findings are based on his observations of patients over a ten-year period who, in this period, developed grinding and clamping habits. None of the previous investigators had studied the same individual through different periods of his life. Leof also stated that, with these habits, a patient develops hypertonicity of the masseter and temporal muscles, without a balancing hypertonicity of the depressor muscles which shortens their effective length at the rest position at the expense of the free-way space.

In any case, when the rest position of the mandible is constant, the levator and depressor muscles are, theoretically, in a coordinate equilibrium, and "rest" is involuntarily assumed after speech or deglutition.When the teeth are out of occlusion and at the rest position, a free-way space exists. During speech, the lower teeth partly traverse the free-way space while, in the act of swallowing, they completely traverse the free-way space.[13]

COMPLICATIONS DUE TO INCORRECT MEASUREMENTS

Free-way space has been defined by some investigators as the space between the maxillary and mandibular natural or artificial teeth when the lower jaw is at

the rest position. For successful prosthesis, other factors being equal, the prosthodontist must determine, as accurately as is humanly possible, the rest position of the mandible with the proper amount of free-way space. If the free-way space is too great, the "bite" is considered closed; if it is too small, the "bite" is considered open.

If the "bite" is closed, there will be a loss of muscular power, and marked changes in facial expression will occur. The muscles of mastication and facial expression are shortened, the anatomic angulation between their points of origin and insertion is changed, and they are unable to exert their maximum tension. This decreased tension, in turn, causes them to lose tone, just as any muscle tissue does when it does not receive enough exercise. Smith[1] claims that "the lips fold inward, furrows and wrinkles are formed, and the face becomes prematurely old in appearance."

Decreasing the free-way space beyond the physiologic limits of the muscles —"open bite"—also results in a diminished masticatory power because the muscles are in a continual state of strain. The patient feels uncomfortable, and he cannot find the cause. During speech, a clicking results. The patient may find it difficult to put an average bite of food in his mouth, and those patients who do not have long flexible lips show an expression of strain.[1] Patients may become adjusted to a "closed bite" but almost never to an "open bite."

With an abnormal free-way space, the function, phonetics, and esthetics of the prothesis will undoubtedly be affected and will consequently cause hardship and suffering to both the patient and the dentist. The signs and symptoms of an improper free-way space are quite classical: clicking dentures, esthetic disharmony of lower third of face, fractured artificial teeth and denture bases, midline fractures in restorations, poor retention, inability to chew well, grinding and gritting of teeth, extrusion of crowns, herpes, loss of alveolar bone associated with flabby ridges, temporomandibular pain, sore ridges, sore tongue, tired feeling, tinnitus, loss of hearing, migraine headaches, and sore muscles.

THE AVERAGE FREE-WAY SPACE

Since the human element is involved, the free-way space varies from one person to another and may vary from one particular person through different periods of his life. There is as much variance in the amount of free-way space as there is in the size of teeth, size of noses, or size of persons.[15]

The average free-way space has been reported as measuring 4/32 inch, 2.5 mm., 3 mm., 3.25 mm., 3.5 mm., 2 to 4 mm., 1 to 4 mm., and 1 to 3 mm. These figures represent an average, not an exact measurement, for this distance, and there have been cases reported where patients have been quite comfortable with free-way spaces measuring 0 mm., 1 mm., 5 mm., and 8 mm. These slight differences in the average free-way space suggest that there is something intangible about it, and perhaps more undiscovered information will be needed before it is thoroughly understood. These variations in the average also suggest that the free-way space may be increased or decreased by a slight amount without causing any discomfort. When a patient is given an average free-way space, he either ends up with his

exact or a compatible free-way space or, unknowingly, becomes easily adapted physiologically to such a small deviation from his exact free-way space.

It must be remembered that the free-way space is an intangible and variable distance depending upon many factors, such as attrition, head size, and habits and changes of the muscles of mastication and facial expression.[1-15]

Since facial expression is an important factor in determining the accuracy of the free-way space, Smith[1] believes that the dentist may benefit by taking into consideration the length of the upper lip. According to Smith, there are three lengths of upper lips:

1. *Short.* When one smiles, laughs, and talks, it is raised so that the alveolar ridge is brought into view.

2. *Intermediate.* During speech there is a moderate degree of tooth exposure.

3. *Long.* Through speech, laughter, and even relaxation of lips there is little if any tooth shown.

Smith claims the long upper lip causes the most difficulty in determining the free-way space because it can cover the labial aspect of a denture quite readily.

Determining the free-way space becomes more difficult when the patient becomes partially or totally edentulous, especially if he became edentulous through an irregular loss of teeth.[15] This causes the muscle pull to be out of balance and the bony relations to be changed. Thus, the free-way space has been destroyed in most cases, and its registration is of little value.[15]

THE USE OF PHONETICS

The use of phonetics in determining the free-way space has been studied and employed for a long time. Having the patient pronounce the letters "m," "s," and "f" and repeat words like "Mississippi," "Tennessee," "if," and "of" has been handed down through the years. According to Silverman,[9] an accurate centric relation in the natural dentition can be measured by determining the position of the mandible during speech or during the pronunciation of various phonetic sounds. He has measured, in units of millimeters, the distance between the upper and lower teeth from centric occlusion to the various levels of speech, using various consonant and vowel sounds. Silverman states that some phonetic sounds cause the mandible to be close to the maxilla, others cause it to be far from the maxilla, and still others cause it to be in between the closest and furthest levels. Therefore, three levels exist in the speaking range: (1) speaking centric level (closest speaking level), (2) widest speaking levels, and (3) intermediary speaking levels.

Silverman found that the speaking centric level (closest speaking level) gives the most accurate results in determining the vertical dimension because the mandible is usually constant when the phonetic sounds of this level are enunciated. The distance between centric occlusion and the speaking centric line is the speaking centric space. This is the distance Silverman measures in determining the vertical dimension, instead of the free-way space, because he found that determining the free-way space was too difficult and could not be relied upon, whereas the speak-

ing centric space of each patient is constant when measured under identical conditions of posture and vigor of speech. He found, after examining 208 patients, that the speaking centric space in different people varied from 0 to 10 mm.

A FEW CLINICAL TECHNIQUES

Before delving into a few clinical methods of measuring the free-way space, it should be stated that almost all investigators agree that the patient should be seated so that his head and body are in a normal upright position, whereby the normal position of his jaws may be measured.

Some men claim that the exact free-way space of a patient can be determined by taking cephalometric roentgenograms of the jaws prior to tooth extraction. These men have developed a variety of x-ray techniques for this purpose.[2-8] They base their findings on the fact that their measurements are taken between two points that are established on hard tissue.

Most dentists agree that the use of mechanical devices such as the jaw relator,[2,3] bite gauges,[16] and Bimeter,[10] in determining the free-way space is only a near corroboration[13] to the keen sense of perception of the prosthodontist, who is guided by physiologic functional movements of the mandible.

Niswonger[2,3] uses the patient's "tactile muscle sense of centric relation" in measuring the free-way space. He assumes that the rest position remains constant throughout life, and the edentulous patient will sense when he is at "rest" and when he is in "centric." His measurements are taken from a point at the juncture of the philtrum with the nasal septum to a point on the center of the chin. It would seem the error hazard would be greater, since his points of measurement were made on soft movable tissue.

Thompson[4, 5] also believes in the constancy of the rest position and obtains this relaxed position through the use of phonetics. He then requests the patient not to move his jaws while he inserts a rapidly setting plaster to fill in the free-way space of a natural dentition.

Gillis[18] uses the letter "m" to obtain "rest" and then directs the patient to "swallow" into centric occlusion, whereby the original or a comfortable free-way space is established.

Boos[10,11] believes in fatiguing the muscles of mastication so that the mandible will move into the rest position. With extremely nervous patients, he uses sedatives. Boos takes his measurements from the tip of the nose to the tip of the chin. This greater distance that has to be measured may also increase the error factor. Boos invented an instrument called the Bimeter, whereby he could measure the free-way space by using the maximum biting power as a gauge.

Boyle,[21] in measuring the free-way space, claims that when the patient says the letter "f" with the upper occlusion rim in his mouth, the lower lip should just make a definite contact with the upper occlusion rim. He also believes in taking a full scale photograph of the lower third of the patient's face while the natural dentition still exists.

CONCLUSION

It seems quite evident from the material that has been presented that not one scientific and absolute method whereby an exact free-way space can be determined and measured is available at present. The intelligent prosthodontist will rely on more than one technique, or a combination of techniques, to reach this end.

I wish to express my sincere thanks to Dr. Philip Williams, Assistant Professor of Prosthetics, Tufts College Dental School, for his aid in selecting the title of this essay.

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A SELF-LOCKING POSTERIOR ATTACHMENT FOR REMOVABLE TOOTH-SUPPORTED PARTIAL DENTURES

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FREQUENTLY, IT IS expedient to design tooth-supported partial dentures for either dental arch in such a way as to achieve greater support and stability for the abutment teeth than could be obtained with fixed bridges. The most frequently encountered situation requires a distal extension partial denture on one side of the dental arch, with a tooth-supported retention on the opposite side. Previous articles have described the application of the distal extension portions of such dentures, and the utilization of multiple interlocking abutments and internal attachments with positive locks.[1,2] The use of such manually manipulated latches as have been described is obviously limited to two in an arch. In short-bite cases particularly, the use of precision-manufactured attachments, dependent upon friction for retention, is highly unsatisfactory. The posterior attachment which will be described was developed to meet the requirement of a positive self-locking, posterior attachment which requires no force to put to place nor to remove. This attachment is most applicable to short-bite cases in either arch, and is limited by the vertical length of the most anterior pontic required in the denture.

Many years ago Hollenback[3] described a hook attachment for the counterbalancing side of a distal extension partial denture where no teeth were supplied on the balancing side. This retention device suggested the possibility of utilizing the principle in a different direction, i.e., anterior-posterior, and supplying support against occlusal forces as well as resistance to displacement.

ATTACHMENT

This attachment consists of a male portion with a two-surface contact on the abutment casting which has two receptacles (Fig 1). The fulcrum is on the occlusal portion.

A broad, relatively shallow dovetail is prepared on the mesial occlusal portion of the abutment casting by cutting through the marginal ridge. The sides of this dovetail cut are rounded to the center, and this must be accurately controlled, particularly on the mesial portion of the dovetail. The required thickness of the male portion of the attachment which will fit into this occlusal step is governed by the degree of occlusal stresses anticipated. Gingivally and in the buccolingual center of the mesial surface of the abutment casting, a rounded

Read before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 3, 1951.
Received for publication June 25, 1954.

depression is cut following the general curvature of the floor of the occlusal dovetail. The thickness of gold in the casting between the floor of the dovetail and this cut in the mesial surface governs the strength in resisting displacement forces. Since the rotation center, or fulcrum of the attachment rotating into position, will be the distal portion of the dovetail, obviously, the closer to the occlusal dovetail the horizontal stud is, the simpler the insertion. This stud, which will fit into the depression on the mesial surface of the abutment casting, does not require great depth. Its sole purpose is to prevent occlusal displacement after the attachment is rotated into full contact with the mesial and occlusal surfaces of the abutment casting (Fig. 2).

Fig. 1.

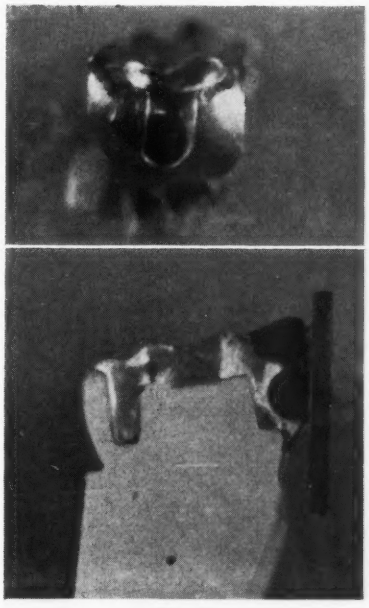

Fig. 2.

Fig. 1.—The mesial and occlusal surfaces of a distal abutment casting with the receptacles prepared.

Fig. 2.—Cross section of a distal abutment casting prepared, with the wax pattern of the male attachment in the receptacles. The excessively long wax truss is for demonstration only.

TESTING OF ATTACHMENT DESIGN

When the receptacles in the distal abutment casting have been prepared to what appears the required degree, a hard inlay wax pattern of the male portion is made and tested, by means of a right-angle sprue, for precision and freedom in movement, as well as for positive locking against vertical displacement. When satisfactory, the wax pattern of the male attachment is invested and cast the same as an inlay.

PREPARATION OF ANTERIOR ABUTMENT CASTINGS

The female slots in the distal surfaces of the anterior abutment castings must be prepared on an arc with a radius centered on the fulcrum point of the posterior

attachment. Since these slots are tapered, it is surprising what a small degree of arcing is necessary to allow free insertion of the male portion of the appliance. By waxing an extension wire or even a wood applicator to the distal male attachment, the necessary arc may be approximated. As the preparation of this female slot in the anterior abutment progresses, it is frequently tested with a wax pattern attached to the extension from the distal attachment until the proper angle and curvature of insertion is achieved.

This same procedure is then duplicated for the opposite side of the arch. If two distal abutments are used (i.e., for a bilateral tooth-supported removable partial denture), care must be taken that the posterior attachments have similar arcs of removal and insertion. If a unilateral distal extension and tooth-supported balancing side are being designed, the anterior abutment preparations have only to harmonize with the single posterior attachment.

Fig. 3.

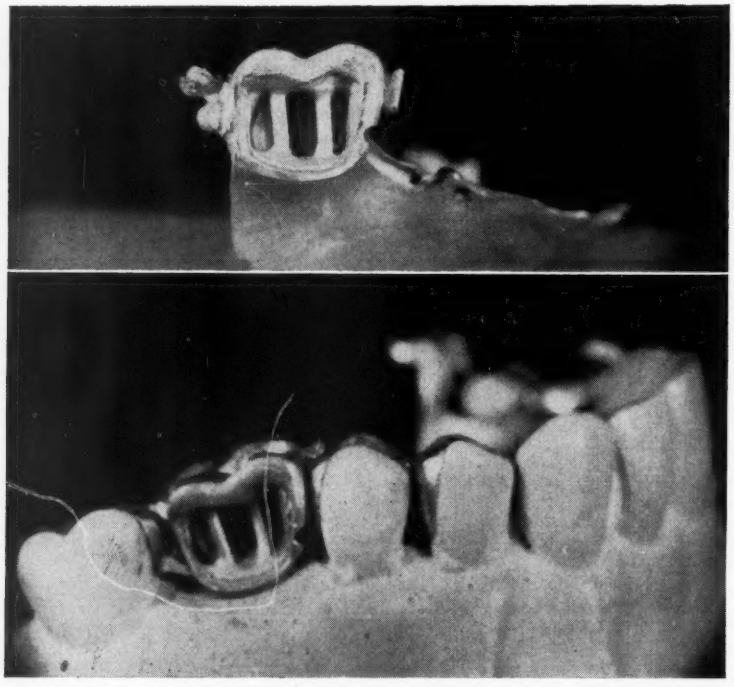

Fig. 4.

Fig. 3.—The male attachment attached to the pontic casting.
Fig. 4.—A partial denture casting rotating into position on the master cast.

PONTICS

As previously stated, this design is most particularly adapted to short-bite cases. The length of the anterior pontic, if excessive, requires that the gingival portion be so far distally from the anterior abutment that an unsightly and unhygienic embrasure may be formed. This gingival point of the anterior pontic must fall within an arc described by a radius centered on the fulcrum point

of the distal attachment, and extending to the most distal portion of the contour of the anterior abutment. This can be determined approximately by careful survey of the working cast before any construction is begun. If the vertical length of the required pontics appears to require for clearance in rotating into place too great an embrasure for esthetics, then this type of posterior attachment should not be used.

A.

B.

Fig. 5.—A maxillary tooth-supported partial denture: *A*, right side; *B*, left side. Periodontal conditions indicated maximum support for abutment teeth. After four years of use, all abutments remained firm and stable.

DUPLICATION OF CAST

When the proper abutment casting preparations have been made, the posterior attachment is placed in its proper position on the posterior abutment. After appropriate wax blockouts of undercuts, the working cast, with the prepared abutment castings in place, is duplicated in reversible hydrocolloid. After separation of the hydrocolloid impression from the working cast, the posterior attachment may be removed from the distal abutment and placed in the hydrocolloid impression before pouring the refractory cast if it appears feasible. If there is any doubt about ability to retain this posterior attachment in its proper position in the impression during the pouring of this refractory cast, it should not be attempted, but the cast should be allowed to duplicate the posterior attachment in the refractory investment.

WAX-UP

If the posterior attachment has been transferred to the refractory cast, the anterior surface of the truss may be lightly coated with Parr's flux wax prior to applying the casting wax to be used, and the waxing of the partial denture carried forward as usual. In the event the male distal attachment is reproduced in the refractory investment material, then the waxing of the saddle truss is made to it for subsequent soldering of the two parts. From this point on, the waxing, casting, and finishing methods previously described are followed[1,2] (Figs. 3 and 4).

Fig. 6.

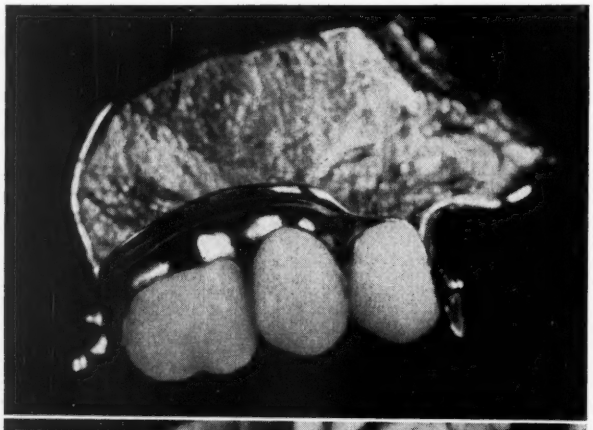

Fig. 7.

Fig. 6.—A bilateral maxillary tooth-supported partial denture. The patient, 30 years of age, had gone eight years with no replacement of the edentulous areas in both maxillary and mandibular arches. All mastication had been done on the anterior teeth. The character of the supporting bone and jaw relations indicated the need for maximum support for the abutment teeth.

Fig. 7.—A maxillary tooth-supported partial denture with bilateral replacements, and supplying four incisors.

DISCUSSION

The distal attachment described has been used for a number of years, and there has been no apparent wear on any of them, since there is no movement when the attachment is in position. At no time has any breakage occurred. This appears to be most applicable in cases of long-span replacements, because, under these conditions, the arc described in insertion and removal is sufficient to allow a normal-appearing anterior pontic. Obviously, in the case of extensive gingival recession on the anterior abutment, such an appliance will be very unsightly

as the arc required for insertion places the gingival portion of the pontic too far distal to the mesial abutment. The advantages of the attachment over spring locks or latches, in which metal fatigue ultimately can occur, are obvious (Figs. 5 to 7).

SUMMARY

1. A positive-locking posterior attachment for tooth-supported partial dentures has been described.

2. This attachment is limited in its application by the length of span of the pontics to be supplied and by the vertical length required in the most anterior pontic.

3. Where indicated, it reduces the number of attachments dependent upon either friction or resiliency of metal retainers.

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INVESTING IN THE UPPER HALF OF THE FLASK

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TO AVOID TRAPPING air bubbles in the interproximal spaces during flasking procedures and to copy in better detail the wax carvings on dentures, scrub a thick mix of stone investment over the wax denture with a small, soft bristled tooth brush until a thin, almost transparent layer of stone covers the wax and teeth. Once the surface tension is relieved by this scrubbing action, the remainder of the investment can be placed quickly. This technique avoids the dangers of vibration and allows the use of a strong, quick setting investment for the primary covering over the teeth and wax.

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Received for publication Aug. 28, 1954.

PRACTICAL PARTIAL DENTURE RESTORATIONS

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PARTIAL DENTURES can give excellent service for many years without destroying either weak or strong abutment teeth. Proper engineering, which includes proper application of forces, proper position of rests, removal of lateral and protrusive interference, and proper fit are the prime factors of a good partial denture.

It is wrong (a) to place a rest on the inclined planes of the lingual surfaces of cuspids and incisors, (b) to place an occlusal rest on the lingual side of a lingually inclined lower molar or bicuspid, (c) to place a rest on the buccal on the buccally inclined upper molar or bicuspid, (d) to place an abutment tooth in a viselike cast clasp where there is no posterior support, unless the tissue and bone are unusually firm, or unless other allowance has been made for the resiliency of the tissue, such as by relining the appliance, or by using a stressbreaker.

A precision attachment appliance will not retain abutment teeth longer than any other type of appliance (except from the standpoint of decay).

Stress breakers are not necessary, even though I have some partial dentures with stress breakers which have been in use for over fifteen years. By the same token, some clasp and precision attachment dentures have lasted longer on the same type of abutment teeth. If stress breakers are necessary, it would be in a partial denture where only one side is tissue-borne. The tissue-borne partial dentures or those in which at least one side is tissue-borne, are the appliances that have caused the most destruction in the mouth.

Frankly, I am almost radical on the subject of saving teeth, and in my practice I make very few full dentures. Many weak abutment teeth, even those with the bifurcation or trifurcation above the bone, can be saved for many years of service without infection.

OCCLUSION

During the first few months, and even years, after partial dentures are placed in the mouth, there will be some change in the denture-bearing tissue as well as in the abutment teeth. This will happen to a certain degree, regardless of the jaw registrations made, the type of instrument the partial dentures are constructed on, or the type of cusps used. Therefore, it is imperative that the patient return every few months after the partial denture is placed to have the occlusal balance checked so that excessive stress on abutment teeth and any lateral or protrusive interference may be removed. The work load of weak abutment teeth should be minimized greatly.

Read before the Academy of Denture Prosthetics at Miami Beach, Fla., April 12, 1954.
Received for publication June 23, 1954.

Bilateral balanced occlusion is not necessary in partial dentures or a natural dentition, but (a) the occlusal area of contact should be very small, and it should not be more than 1 to 2 mm. in diameter on weak abutment teeth; (b) any tooth that moves when lateral or centric occlusal contacts are made will cause bone resorption around it, and this interference must be corrected; (c) every weak abutment tooth must have the occlusal stress directed through the strongest part of the tooth. On lower posterior teeth, this means that the stress should be placed upon buccal inclines; and on the upper teeth, it should be placed upon the lingual inclines.

ATTACHMENTS

No partial denture attachment should fit the abutment tooth so tightly that it cuts off circulation from the tissue in the saddle areas, thereby causing resorption. Every attachment and clasp should be loose enough on the abutment tooth to allow the appliance to release itself after pressure has been applied. This is the reason I use a clasp consisting of a cast occlusal rest, a cast lingual arm, and a buccal arm extending about 2 mm. onto the buccal surface of the tooth with a 20 gauge stainless steel wire, which is attached in the plastic and which contacts the buccal surface of the tooth, to act only as a retainer. This clasp causes no distal stress on the abutment tooth. The cast *buccal* extension of the lingual arm prevents lateral thrust. If an all metal base is used, the wire buccal arm of the clasp is soldered to the metal base.

When precision attachments are used, they are made to fit very loosely and act only as stabilizers and stops for the appliance.

If necessary the bottom is cut out of the attachment, making the denture almost completely tissue-borne. On the lingual side of every attachment, a 20 gauge tension wire is used for retention. This wire is placed below the lingual bulge of the tooth and allows the appliance to release itself after pressure is applied, but it still retains the appliance.

A number of Roach or modified Roach clasps are used. Some of these are used without occlusal rests when that is indicated, as in situations where only one side is tissue-borne.

Weak abutment teeth should be splinted together to add years of service. As few as three teeth have been splinted together and used to stabilize appliances satisfactorily for over fifteen years.

The home care of the appliances and the abutment teeth must be stressed during the first few months of use of partial dentures. The patient must cooperate or take the blame for decay and other trouble.

Practically any type of partial denture that is properly engineered and constructed can give years of good service, whether attached to good or weak abutment teeth, if it is properly checked and balanced at least every six months and provided the patient cooperates with good home care.

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PRESERVING NATURAL TEETH THROUGH THE USE OF CLASPS

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THIS IS A DISCUSSION of how natural teeth may be preserved in spite of the compulsory use of clasps. Clasping a natural tooth is not a step calculated to enhance its preservation, as clasps generally represent a necessary evil —necessary to support and retain substitutes for the teeth missing in the dental arch. And yet when all that can be said has been said against clasps, the law of compensation can say some very complimentary things. So let us proceed to analyze the nature of the clasping problem to see what is right and what is wrong with it.

It is unfortunate that the term *clasp* has received such a foothold in dental nomenclature. A clasp is generally mentioned without any qualifications and without an appreciation of its dual function, namely, to retain and to stabilize.

In the early thirties, the idea occurred to me that clasps could be classified into two general categories: (1) suprabulge design, (2) infrabulge design. The suprabulge design would embrace all circumferential clasps such as the vertical, diagonal, and horizontal types. The infrabulge design would include the Bonwill,[1] Roach,[2] and the embrasure-saddle clasp designs (Fig. 1).

In 1936, I[3] discussed the advantages of such a classification. As some of you may recall, I listed the advantages and disadvantages of both the suprabulge and the infrabulge designs.

The differentiation is based on the mean direction of the clasp arm as it approaches the undercut plane. Direction is reckoned with the cast in hand and not as seen in the mouth. With the suprabulge design the clasp arm approaches the undercut from above, extending from the occlusal rest downward, or downward and across to the undercut plane. The infrabulge design has the clasp arm approaching its undercut plane from below, coming up from the region of the saddle (Fig. 2).

On first thought, this difference in approach appears insignificant, yet it is my opinion based on over twenty years of extensive clinical application, observation, and reflection that it may account for the difference between a helpful or a harmful clasp. We shall develop this thought as we go along.

Illustrations for this article were done by Dr. P. Souza Cordiero of Bombay, India, a graduate student in Prosthodontics, in the Graduate School of Medicine, the University of Pennsylvania.

Reprinted from the Fortnightly Review of the Chicago Dental Society 27:7-12, 1954.
Read before the Midwinter meeting of the Chicago Dental Society, February, 1953.
Received for publication May 10, 1954.

Let me say to begin with that we do not advise the use of clasps for the sole purpose of splinting teeth. Full coverage crowns, even though they require the radical removal of tooth structure, may in the long run prove conservative by preserving the periodontal membrane and its enveloping alveolar bone. When two or more teeth are thus joined, they constitute the ideal splint.

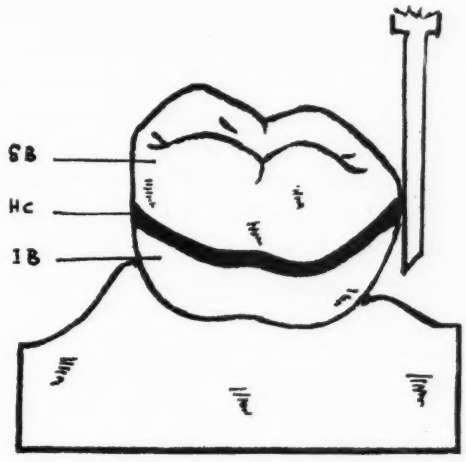

Fig. 1.—*SB*, Suprabulge or nonundercut area. *HC*, Survey Line. *IB*, Infrabulge or undercut area.

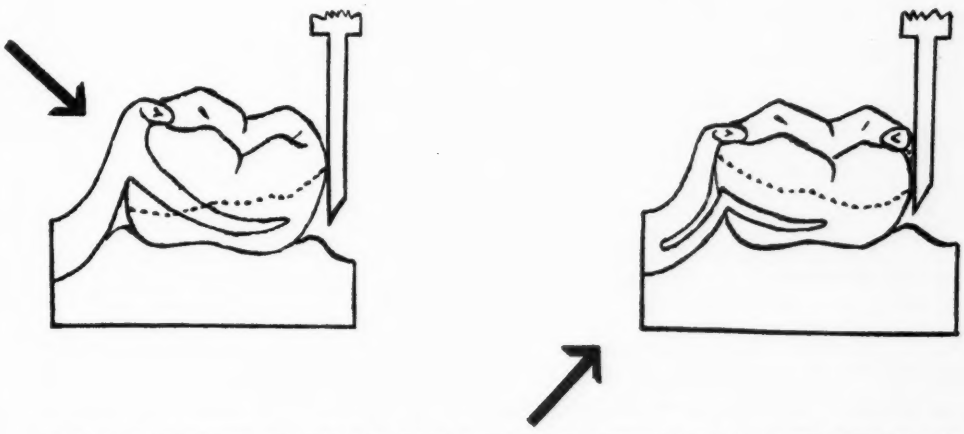

Fig. 2.—The arrows indicate the mean direction of approach of the clasp arms to the undercut areas. With the cast in hand, the direction of approach is from above in the suprabulge design, while it is from below in the infrabulge design.

Our concern with clasps is based on the necessity of supporting and retaining partial dentures. The following discussion of clasps, therefore, will center about their aid in partial denture design.

SUPPORT OF PARTIAL DENTURES

A partial denture needs to be supported as well as retained. Support is provided by occlusal rests and parts of the clasp arms above the survey line;

retention is provided by the part of the clasp below the survey line contacting the undercut area. There are essentially three kinds of support: saddlewise, buccolingual, and mesiodistal.

Saddlewise support provided by occlusal rests results in essentially axial forces to the abutment teeth. Buccolingual support provided by the shoulders of suprabulge clasps in function may result in transverse forces to the abutment teeth. Mesiodistal support is provided by the vertical uprights or struts that unite the occlusal rest with the body of the partial denture.

Saddle teeth, provided they are in meticulous contact with the proximal surfaces of the adjoining natural teeth, also help to support the natural teeth in a mesiodistal direction.

Horizontal forces on a tooth are better resisted in a mesiodistal direction than in a buccolingual direction. Usually the primary abutments have adjoining teeth mesially or distally to help resist mesiodistal forces, while buccolingual force must be absorbed by the abutment teeth alone. The infrabulge design avoids the use of clasp shoulders that traverse the abutment teeth buccally and lingually above the survey line. This minimizes the possibility of buccolingual movement of the abutment teeth during mastication (Fig. 3).

Fig. 3.—Buccolingual section along the long axis of a tooth through the occlusal rest and clasp arms. During function, the infrabulge clasp on the right is inactive but the suprabulge clasp on the left transmits lateral force components buccolingually due to the shoulders of the clasp arms riding on an incline. Note also that the suprabulge clasp arms change the contour of the tooth.

The clasp arm of the infrabulge design is essentially a retainer—resisting vertical countersaddlewise force. It does very little stabilizing in a buccolingual direction, and as a consequence its presence results in a negligible degree of buccolingual force on the abutment teeth. In regard to immobility of abutment teeth, there is a differential of 17 to 1 in favor of axial forces. If one unit of force is required to displace an abutment tooth transversely, 17 units of force will be required to displace an abutment tooth the same distance axially.

It is difficult for me to believe that partial dentures can be constructed that do not move in function. In the first place, a mouth requiring a partial denture is a partially mutilated mouth. Probably none of the abutments have perfect periodontal and osseous support. Then again, considering the complicated procedure involved in the fabrication of metal partial dentures, the human element is such that precise and simultaneous seating of all its parts is the exception rather than

the rule. Assuming that this seating was precise, what assurance have we that mouth changes would not occur that will result in some movement during function?

During functional movements, clasp parts such as rests and their vertical uprights, parts that provide saddlewise and mesiodistal support are likely to prove physiologic to the abutment teeth, while clasp parts such as shoulders and arms may prove to be traumatogenic because they provoke buccolingual displacement of the abutment teeth (Fig. 4).

A clasp unit consists of retainer and stabilizers—retainers to resist counter-saddlewise forces and stabilizers to resist saddlewise, buccolingual, and mesiodistal forces. A partial denture need not be stabilized to function; however, it must be retained to be of any use. When a partial denture possesses sufficient retention and insufficient stability, its use may result in injury to the supporting structure.

Fig. 4.—*R*, Rigid for support; *S*, Spring tension for retention.

The partial denture problem is to supply substitutes for the missing teeth without injury to the remaining teeth. When properly designed, a partial denture with minimal retention and maximal stability should not only supply the missing teeth but also support the remaining teeth axially and mesiodistally. It is inconceivable for a partial denture to be overly stabilized but it may be excessively retained. Stabilizers employing abutment teeth to support the partial denture confer a benefit through mutual abutment support. This is not true of retainers; retainers are always a liability to the abutment teeth. They contact the sides of the teeth causing transverse loads. Clasp retainers are a necessary evil and should be sparingly employed. It is generally wise to use one clasp arm and two occlusal rests on each abutment tooth. The embrasure-saddle clasp, an infrabulge design, usually consists of a single clasp arm and double occlusal rests.

RETENTION OF PARTIAL DENTURES

It has been my observation that partial dentures need not be overly retained when they are sufficiently stabilized. Retentive forces should concern themselves principally with overcoming the force of gravity and the pull of adhesive foods.

A partial denture may be retained by the following forces: (1) spring tension, (2) frictional force, (3) force of adhesion, or interfacial surface tension, (4) atmospheric pressure, (5) force of gravity (in lower dentures).

This article is limited to a discussion of retention secured by means of spring tension and frictional force—retention provided by clasp parts. This should be said about nonclasp means of securing retention however—they should be employed to their fullest extent. In fact, a partial denture should be so designed that it could function without spring tension retainers after the appliance has been worn for some time.

Clasp parts provide two means of retention, namely, spring tension and frictional force. Spring tension is the simplest and most effective means of securing retention, but, as we have stated above, it is apt to be dangerous to the welfare of the abutment teeth. This danger is reduced when spring tension bearings are limited to proximal surfaces.

I am deeply impressed with the superiority of infrabulge retainers in function for the following reasons:

1. Infrabulge clasps are passive during rest periods; their bearings become effective only when retention is in jeopardy. A suprabulge clasp may also be made passive by judiciously relieving the inside surface of the shoulders and arms of the clasp. This procedure, however, has other drawbacks.

2. Infrabulge clasps do not materially alter the contour of the abutment teeth. Clasp shoulders on the occlusal cone are not present to obliterate occlusal embrasures and to extend the contour of the tooth buccally and lingually. An increase of buccolingual contour may prove dangerous. In the presence of a resistive bolus, contour constituting a subocclusal area may actually be in contact.

3. Infrabulge clasps generally approach their undercut planes more nearly at right angles and thus increase the degree of retention. The angle of incidence of clasp arm to undercut plane is more nearly at right angles when the undercut is approached from the saddle rather than the occlusal cone of the tooth.

4. Tripping action is evoked while removing the partial denture. With suprabulge clasps, tripping action is evoked while seating the appliance. According to Stone of Washington, tripping action may increase the retentive force as much as 143 per cent. Tripping action offers resistance to traction and as a consequence, shallow undercuts may be employed, requiring less flexion of clasp arms resulting in less displacement of abutment teeth (Fig. 5).

5. Retainers do not interfere with seating. Infrabulge retainers being separated from stabilizers cannot interfere with the seating of the occlusal rests. The principle of separating retainers from stabilizers and joining them separately to the saddles was first recognized and employed by Bonwill. We regard it as an important principle in the overall strategy of protecting abutment teeth from excessive mobility. The annoying phenomenon of a slight spring when trying to seat a newly constructed partial denture is conspicuously absent with the infrabulge design.

A final word on the principles involved in securing retention of a partial denture. Retention results when two or more tooth surfaces are contacted simul-

taneously—two surfaces that face each other or face away from each other and are parallel or converge one with the other. Negatively stated, retention will not result if the surfaces contacted face the same direction, or diverge from each other. Thus, with unilateral appliances, a mesial surface must be combined with a distal surface; a buccal surface must be contacted with a lingual surface. With bilateral

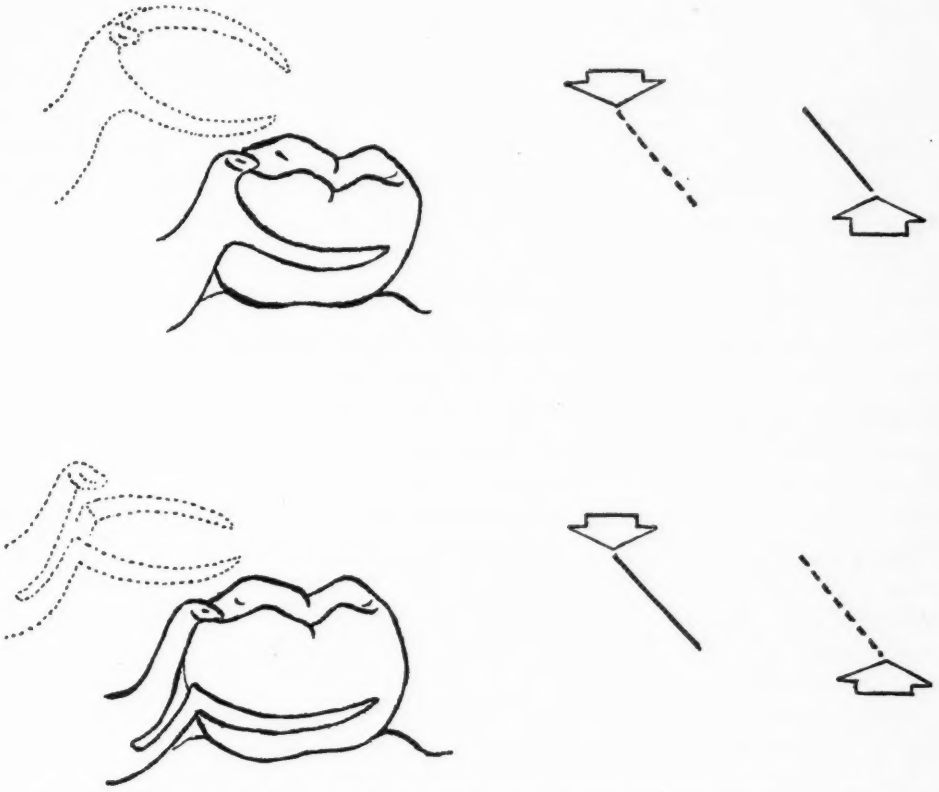

Fig. 5.—Above: Suprabulge clasp—tripping action during insertion. Below: Infrabulge clasp—tripping action during removal.

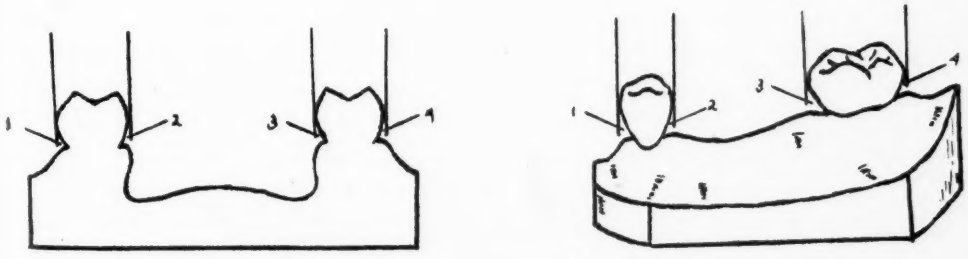

Fig. 6.—Left: *1* and *2*, Retention; *1* and *4*, retention; *3* and *4*, retention; *2* and *3*, retention. Right: *1* and *3*, No retention; *2* and *4*, no retention.

appliances the same rule holds good with mesiodistal surfaces. With buccolingual surfaces, however, the rule does not apply. Two buccal or two lingual surfaces must be combined for retention to result. This is due to the mechanical requirement for retention, namely, two contacting surfaces must either face each other or face away from each other (Fig. 6).

CONCLUSION

1. Clasps should be looked upon as a necessary evil—necessary to retain and support the substitutes for the missing teeth.

2. The portion of the clasp that is most dangerous is the retainer-clasp arm; the portion most beneficial is the occlusal rest, the vertical saddlewise stabilizer.

3. Infrabulge retainers should be used whenever esthetics will permit.

4. Every possible means should be employed to stabilize the partial denture by the extensive use of occlusal rests on auxiliary abutments.

5. An effort should be made to secure retention by other means than spring tension. The possibility of securing additional retention should be explored—retention by contacting two or more parallel surfaces with struts and by meticulous adaptation of saddles and broad ribbonlike connectors with mouth tissues.

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PERIODONTAL ASPECTS OF PARTIAL DENTURE PROSTHESIS

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THE RESTORATION of full function in partially edentulous patients can be approached in several ways. Excellent solutions are sometimes attainable, especially where a combination of restorative techniques can be utilized. In many patients, however, a removable partial denture is the most reasonable solution: in some patients all the post canine teeth of one side are missing; in others, the important and unavoidable factor of finance must be considered. Provided that the appliance restores full function without adverse effects on the remaining natural teeth, it becomes an acceptable and relatively inexpensive solution.

In the design of these removable partial dentures, an attempt is usually made to maintain and even improve the health of the periodontal structures supporting the natural teeth. The methods used include the careful distribution of the occlusal loading, avoidance or minimizing of lateral stresses, and the prevention of cuspal interference during functional movements. Stress-breaking mechanisms are often incorporated in the attachment of retainers and of free end saddles to the main frame in order to similarly render the stresses physiologically compatible.

Wherever there are spaces caused by the loss of natural teeth, it is customary to use saddles, either fully or partly tooth-borne, and these carry the artificial teeth occupying the interdental spaces. It is with the periodontal aspects of these saddles that this article is concerned.

HEALTH OF THE PERIODONTAL TISSUES

It seems to me, that while careful attention is paid to the health of the periodontal membrane, insufficient thought is given to the prevention of irritation to the gingival tissues. While it is probably correct to say that, in those cases where a denture is required, the age and dental condition of the patient tend to direct our attention to the degree of mobility of the teeth and the amount of supporting bone, it is also true that most periodontal involvement starts as an inflammation sited in the free gingivae. Prevention of such inflammation is, therefore, the first step in the preservation of all of the supporting structures. Where there is one tooth missing in the molar region, bridgework will usually supply the deficiency. When, however, the absence of teeth elsewhere in the arch necessitates the use of a partial denture, this same space will usually be filled by a saddle and an artificial tooth, and it is herein that the danger lies of future gingival disturbance. It would certainly be bad practice to cover the free gingivae

Received for publication Sept. 16, 1954.
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closely. In any case, this is seldom a possibility owing to the tendency of the remaining teeth to tip, which gives the interdental space an undercut shape. Thus, there is a small wedgeshaped space left between the sides of the interdental saddle and the proximal surfaces of the natural teeth. This also applies to the mesial surface of a free end saddle, especially for some angles of insertion.

Food particles become packed during mastication into the spaces so formed, and the spaces are usually too narrow for easy clearance later. While it is true that correct oral care requires a thorough brushing of teeth and the denture immediately after a meal, this is just not practicable on many social occasions. The busy worker snatching a hasty lunch may be similarly handicapped. Such impacted material can be a definite irritant. Careful observation demonstrates that any tendency to gingival disturbance is often speedily exaggerated after insertion of conventional designs of partial dentures.

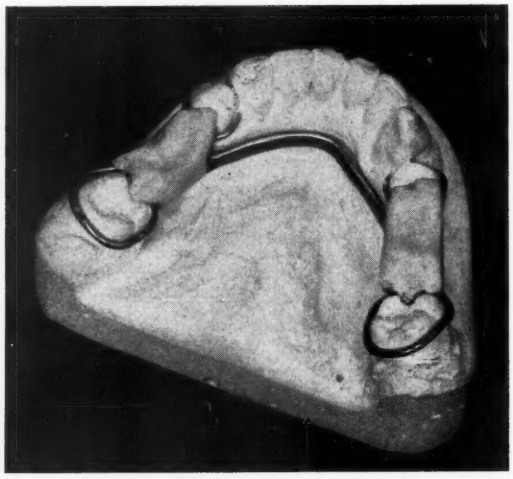

Fig. 1.—A partial denture designed to produce the minimum of gingival disturbance. Note the acrylic resin occluding surfaces.

The ideal is to restore function completely without adversely affecting the supporting tissues. In upper removable appliances, esthetic requirements restrict our ability to achieve this ideal, since the visible parts of the artificial teeth and the base material must be well adapted to the natural teeth for a convincing restoration. In the lower arch, however, these requirements are much less restrictive, and it is especially here that I think a greater freedom in design is possible with the attainment of a more physiologic result. The same line of thought controls our design of fixed bridgework, and while a plain bar bridge without a pontic is seldom esthetically acceptable in the upper arch, it is often good practice in the lower arch. I shall, therefore, suggest a type of lower partial denture in which the essentials of a bar bridge are combined with the more customary features. The aim of minimum gingival disturbance is achieved in these restorations.

A denture fabricated from stainless steel clasp wire and a stainless steel bar is shown in Fig. 1. It can be easily and quickly constructed in order to test the patient's tolerance of such a device (as was done in this case). It was found to be very comfortable and quite efficient. In selected cases, modified designs could even be used as inexpensive permanent appliances, using gold wire if desired. The occlusal tables are formed by the three lengths of wire which constitute the free ends of the clasp arms of each side. Two are from the premolar clasp and one is from the back action circumferential clasp on the molar tooth. The extreme mesial and distal ends of one wire are flattened and adapted to the teeth to act as occlusal rests. These three wires are soldered to a strip which joins the ends of the lingual bar. The whole forms a structure of little weight with considerable rigidity. White acrylic resin is used to form the occlusal surface and to fill in the contours. Fig. 2 shows the clearance space between the mucosa and the denture. It was adequate for the intended purpose for the patient.

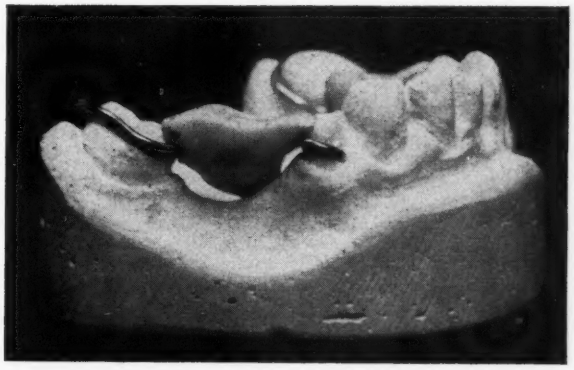

Fig. 2.—The partial denture with space between the acrylic resin occlusal restoration and the mucosa.

The second example is more complicated and is constructed of Vitallium (Fig. 3). The principles discussed above are applied in this denture (Fig. 4). In this case, no additional loading was applied to the second premolar because of an unsatisfactory clinical history. The occlusal rest on the right canine bears on the distoincisal angle and in a small notched rest area on the mesioincisal angle. The labial and lingual parts are cleared slightly from the tooth. The occlusal bar was made narrow because it is in occlusion with a complete upper denture. Occlusion with natural teeth would necessitate modification of the width and the surface contours. On the left side, the saddle is retained by a two-armed type of clasp, the heavier arm also acting as a stress-breaking type of incisal rest. In the finished denture, the anterior pontic has the mesial surface deeply grooved to accommodate the distal clasp. The pontic contacts the canine tooth incisally to the clasp, and below the clasp, the pontic and the resin base slope distally to finish flush with the outline of the metal frame. This gives a tight contact between the pontic and the canine tooth, and yet there is a free space of approximately 2 mm. at the gingival area. This has proved to be adequate for

easy clearance. In this design, the rejection of the usual close fit along the distal surfaces of the canine teeth has made it possible to utilize otherwise inaccessible retentive areas. This has solved what has previously been a difficult case for retention because of the lingual inclination of the canine teeth. A succession of dentures had been unsatisfactory in this respect as well as periodontally.

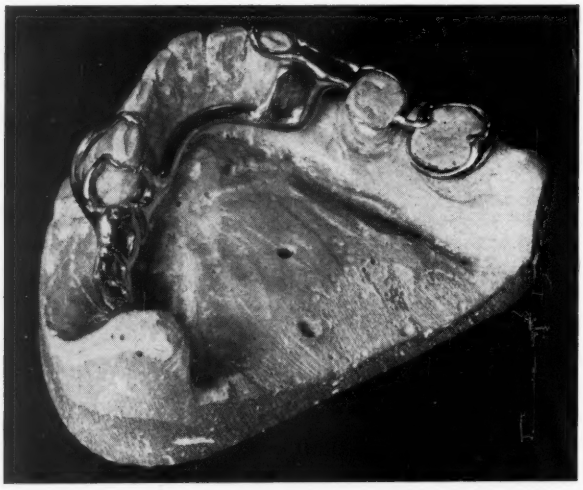

Fig. 3.—The general design of a denture frame. Note the position of the free end of the molar clasp and the spacing of the frame from the distal surface of the left canine tooth at the gingival margin.

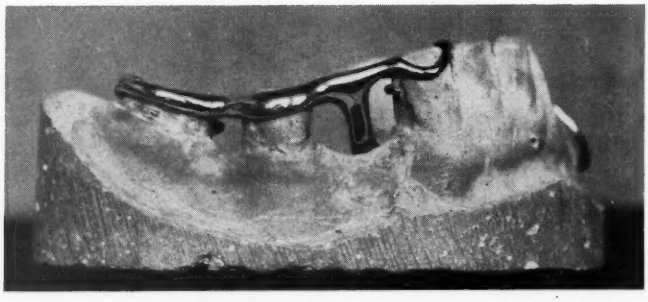

Fig. 4.—The denture frame. Note the large clearance spaces and the retention area made available on the distal surface of the canine tooth.

The incisal loading could have been transferred to the canine teeth by arms arising from the lingual bar with certainly improved esthetics. However, this involves the covering of the gingivae on the lingual side at two more points. This makes the retention of irritating material more likely than that which occurs with labial extensions like the one on the left canine tooth. Labial extensions can usually be given greater clearance and still be well tolerated. I preferred to make esthetics a secondary consideration. The functional results

have been exactly as planned. Most food lodged in the spaces during mastication can be cleared away easily by tongue and cheek movements, while a sip or two of liquid gently flushed through the spaces will complete the clearance.

The placement of the free ends of the molar clasps is carefully planned in both dentures. These ends are tucked well away into the interdental spaces, preventing any conscious awareness of the presence of the clasps. The practice of finishing this type of molar clasp at or on the mesiolingual surface, as often results from a strict adherence to some favored survey line, can lead to poor tolerance of the denture and even a sore tongue. It is better to accept an apparently less retentive path of insertion in order to get the clasp end round the corner of the tooth and thus ensure functional comfort. Moreover, such a clasp can be given considerable springiness if it is made fine enough, even when it is constructed in a chrome alloy. This allows considerable latitude in the degree of undercut.

It must be emphasized that the examples shown are only for the purpose of illustrating a basic attitude to a particular problem of considerable importance—how to restore function without causing a gingival irritation or making one worse. There will be differences of opinion on some aspects of the designs. The details of the way in which the individual attains a given end, however, are usually not as important as a clear visualization of the concept, toward the practical realization of which the effort is being directed. In this way, knowledge and judgment will be in control, and the end result will not be determined by a stereotyped technique.

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COUNTERPOISE PROSTHESIS TO CORRECT EXCESSIVE VERTICAL OVERLAP OF INCISORS

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THE PROSTHODONTIST realizes the importance of reduction of traumatic forces upon the incisor teeth in centric and protrusive occlusions. When premature contacts on certain teeth interfere with simultaneous contact of all teeth in hinge axis closure or when locked cusps and incisal vertical overlap prevent the normal function of bilateral balance in all masticatory ranges, a condition known as functional malocclusion exists.

Interferences between certain teeth, which alter the normal arc of hinge axis closure, can be corrected. Interferences between certain teeth, which prevent normal lateral excursive movements, can also be corrected by occlusal equilibration. Corrective techniques of occlusal equilibration, as prescribed by various authors,[1-4] are now well established and practical. The destructive effects of functional malocclusion can now be greatly minimized.

Relatively few patients will demonstrate continuous contact of the posterior teeth throughout the entire functional range of protrusive occlusion.

In regard to incisal vertical overlap, Schweitzer[5] states: "Where the maxillary incisors overlap the mandibular incisors more than one third without a compensating overjet, we are dealing with a deep bite. A deep bite must not be confused with a closed bite. A closed bite is due to abrasion, either chemical or mechanical, or to a mutilation in some form of the dental apparatus. A deep bite is normal to the individual whereas a closed bite is the result of some disorder. In protrusion, the overbite throws the entire stress of the masticating muscular forces upon the incisors without adequate posterior support. There are many cases in which the incisors cannot tolerate this strain, and in middle or old age, will break down."

In our efforts toward occlusal equilibration, we have been limited in our ability to relieve the trauma imposed upon the incisor teeth in protrusive occlusion. Esthetic and anatomic factors have made it impossible to shorten the upper incisors sufficiently to allow the posterior teeth to come into contact.

It is logical, therefore, to assume that, if posterior balancing support could be supplied throughout the entire range of protrusive occlusion to offset the traumatic forces upon the incisor teeth, the incisor teeth could be relieved of trauma and thereby be retained in a healthy state.

Read before the American Academy of Restorative Dentistry Feb. 8, 1954, and the Chicago Dental Society, Feb. 10, 1954.

Received for publication Aug. 4, 1954.

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Most attempts toward this end have been in the form of increasing the vertical dimension, such as occlusal reconstruction, bite plates, and splints.

It is my contention that, in patients with a moderately deep vertical overlap where the curve of Spee is fairly normal, increasing the vertical dimension is not only unnecessary but, in many instances, to be avoided. Increasing the vertical dimension from that which is normal to the individual by building up the occlusion posteriorly by means of inlays, splints, and bite plates may produce unfortunate results.

THE PRINCIPLE OF PROSTHETIC COUNTERPOISE

Prosthetic counterpoise is the addition of an equivalent power or force which will act in opposition to a force which is destructive to any part of the masticatory mechanism. The discussion of this principle will be limited to the manner in which it applies to patients with a deep vertical overlap, and a technique will be described which is designed to provide posterior balancing support for the relief of trauma imposed upon the incisor teeth during incisive function.

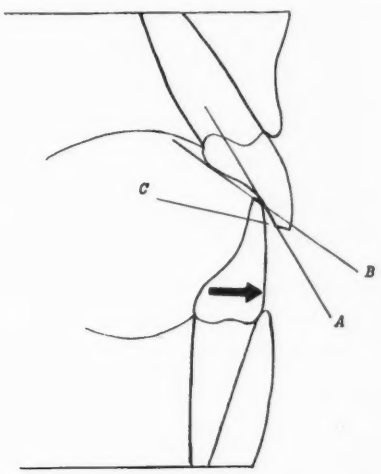


Fig. 1.—The correction of interferences on incisors in protrusive movements. *A*, The path of travel of the lower incisor. *B*, The reduced angulation of the path after correction. *C*, No reduction of the length of the lower teeth may be made.

An analysis of the individual's functional occlusion, by means of study casts mounted upon an anatomic articulator, should be the deciding factor as to the possibility of providing posterior balancing support throughout the entire protrusive functional range. It is imperative that all discrepancies of functional malocclusion are relieved by occlusal equilibration before attempting to provide posterior balancing support. A portion of the stress which is thrust upon the incisor teeth in protrusive occlusion can be relieved by occlusal equilibration. If the upper central and lateral incisors are longer than the cuspids and if esthetic and anatomic factors permit, they can be shortened to partially relieve this stress.

In correcting the gross interferences in protrusive positions, the red and blue technique should be used. Red inking ribbon is used to register centric

occlusal contacts; blue carbon paper is then used to register the paths of protrusive movement. The objective of reduction of trauma in protrusive positions is accomplished by reducing the steep incline (*A*), upon which the lower incisor must travel, to the lesser incline (*B*) (Fig. 1). This reduction must be made upon the upper anterior teeth from the outer edge of the red centric occlusion mark to the termination of the blue mark. The lower anterior teeth should *not* be reduced to incline (*C*) (Fig. 1) in order to allow them to clear the upper anterior teeth. If this grinding were done, the lower teeth would simply extrude and in time return to a traumatic position. This method of selective grinding should be continued until the stress of protrusive occlusion is borne by as many anterior teeth as possible and is functioning smoothly. Esthetic and anatomic factors frequently make it impossible to shorten the upper incisors sufficiently to permit the posterior teeth to come into contact. In these instances, the entire stress of protrusive occlusion is still upon the incisor teeth (Fig. 2).

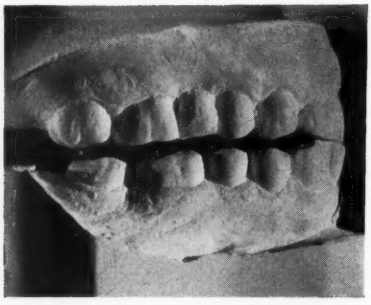


Fig. 2.—Articulated casts in protrusion. Note the heavy incisal contact.

POSTERIOR BALANCING SUPPORT

In traveling from centric (Fig. 3) to protrusive position (Fig. 4), Point A of the lower incisor must move forward and downward along Plane A. Simultaneously, the lower tooth must move downward and forward from Point B along the imaginary plane B. Therefore, if a plane such as Plane B could be established along which Point B could function in harmony with the angle of inclination of Plane A, the stress along Plane A could be reduced during the incisive stroke. The creation of a functional plane, such as Plane B, which would not interfere with centric or lateral occlusions, would provide posterior balancing support in protrusive occlusion and thereby eliminate the trauma upon the incisors with a deep vertical overlap. If the curve of Spee is not too acute and if the inward slope of the upper incisors is not too great, the possibility of providing posterior balancing support is feasible.

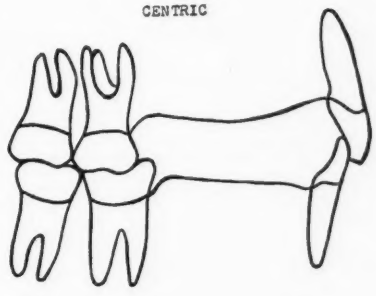
OPERATIVE PROCEDURES

The operative procedures for providing posterior balancing support involve the preparation of mesio-occluso-distal cavities of the slice or slice-lock type, in the first and second molars on both sides of the lower arch. Full arch impres-

sions of both arches are made in reversible hydrocolloid. A stone cast of the upper arch is made in the usual manner.

Dies of the cavity preparations are made in die stone before the lower cast is made. Matrix metal strips are used to prevent the die stone from running together while it is poured into these areas of the lower impression (Fig. 5). The metal strips should be cut long enough to engage the buccal and lingual surfaces of the hydrocolloid between the impression of each cavity preparation. Care should be taken to avoid encroaching upon the impressions of the gingival margins of the cavity preparations during placement of the metal strips. Die stone

Fig. 3.



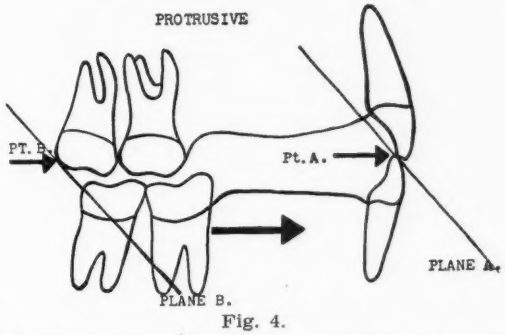


Fig. 4.

Fig. 3.—The mandibular and maxillary teeth in centric occlusion with a deep vertical overlap of the incisors.

Fig. 4.—The mandibular and maxillary teeth in protrusive occlusion. The large arrow indicates the direction of movement. Plane A indicates the path of Point A in this movement. Plane B indicates the path of the lower molar away from Point B.

is mixed to a thick consistency and vibrated carefully into the impression of each cavity until it is filled to a slight excess. Additional die stone powder is sprinkled onto the stone in the impression of each cavity, to bring the stone to a putty-like consistency, and dowel pins are inserted. These pins are carefully centered and aligned over each cavity area (Fig. 6). The impression is then placed in a humidor until the die stone has set. Then the pins and dies are left intact in the impression and painted with petroleum jelly. A thin mix of stone is prepared, and the master cast is poured without vibration to prevent movement of the dies or distortion of the pins or dies. After the stone has set, the master cast is separated from the impression. The dies of the abutment teeth may now be removed, trimmed, and replaced on the master cast (Fig. 7).

A hinge axis locater should be used to establish the definite hinge axis points on the face. The face-bow is then adjusted to these points. The upper cast is then transferred to an adjustable articulator in its correct relation to the hinge

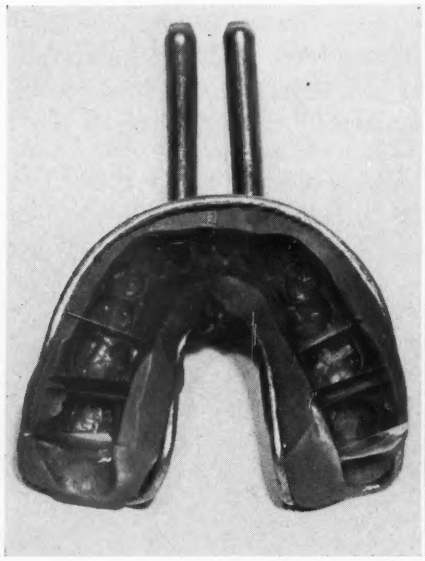


Fig. 5.

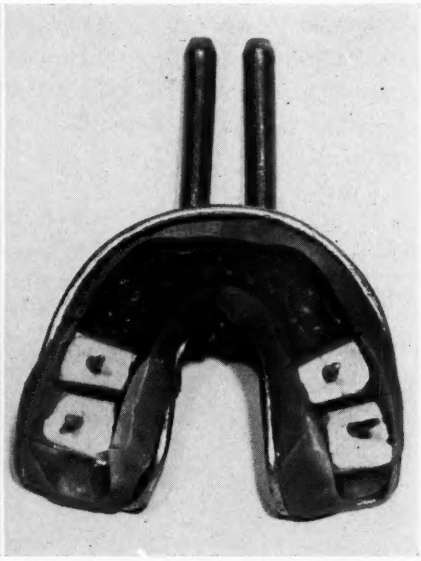


Fig. 6.

Fig. 5.—A hydrocolloid impression, metal matrix band partitions in position for making the dies.

Fig. 6.—A hydrocolloid impression with the dies poured, the pins in place, and the metal partitions removed.

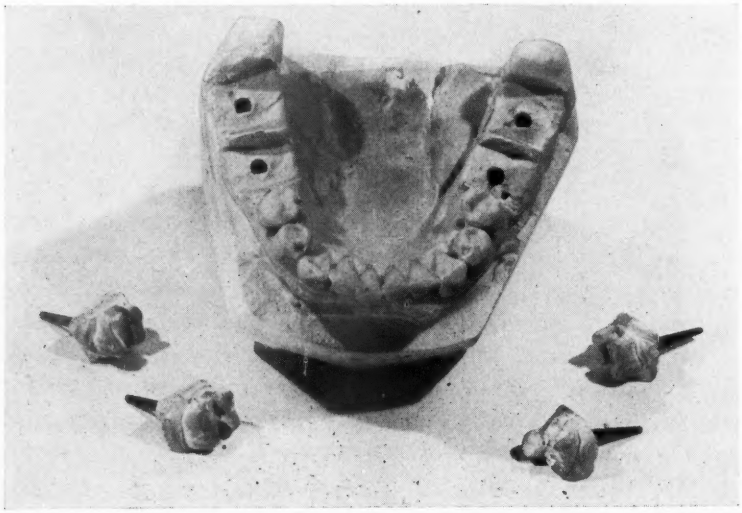


Fig. 7.—The dies have been removed from the master cast for trimming.

axis and orbital axis plane. The lower cast is oriented and mounted in relation to the upper cast by using a centric wax record of the true hinge axis closure. The accuracy of mounting and the adjustment of the articulator can be checked by the use of various checkbite records previously made.

CREATING POSTERIOR BALANCING SUPPORT

Matrix metal bands are cut, fitted, and scribed to embrace the distal part of each lower second molar. The occlusal section of each band should extend well above the occlusal surface of the teeth at the distal of the second molars (Fig. 8).

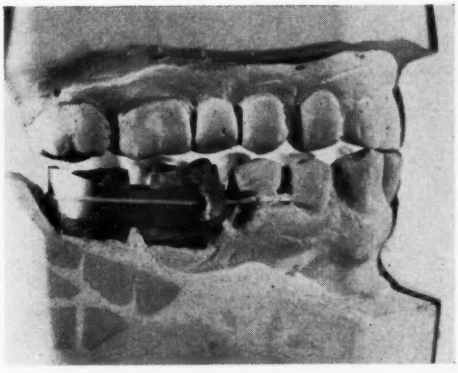


Fig. 8.—The matrix metal band is in position around the two molar teeth. The occlusal height of the band is reduced to allow clearance for the upper second molars in the protrusive positions.

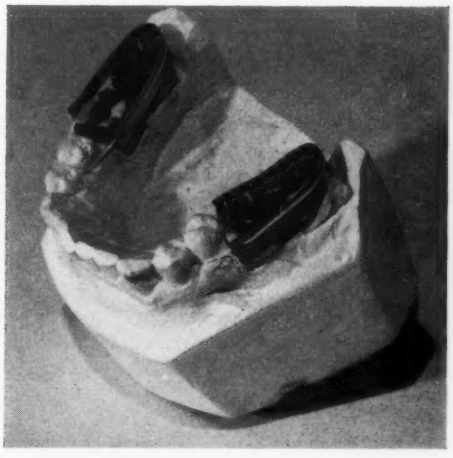
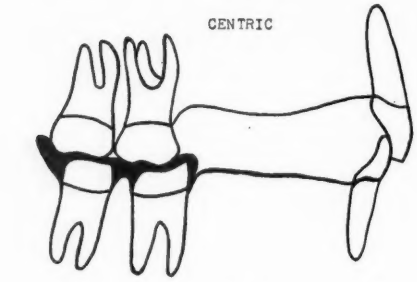


Fig. 9.—The matrices are ligated in position to prevent distortion of the wax patterns while the posterior balancing supports are being developed.

The occlusal height of each band should be reduced, if necessary, to permit clearance for the upper second molars in protrusive occlusion. Holes are punched at each end of the matrix bands, and a ligature is threaded through the holes. The ligature is then brought anteriorly and threaded through a hole drilled between the bicuspid teeth. Then the matrix bands are securely tied in place, and the restorations for the cavities are waxed up as individual units. The second molar patterns are built up in excess at the distal to the height of the matrix bands. The matrices will prevent distortion or dislodgment of the wax patterns when stress is applied during the time of development of posterior balancing support (Fig. 9).

The wax patterns in the dies of the second molars should fit snugly against the distal section of the upper opposing molars and still allow for closing of the articulator in centric relation (Fig. 10). The upper second molars are lubricated, and the wax at the distal portion of each lower second molar is warmed with a blowpipe. The articulator is moved repeatedly from the centric to the protrusive position. This procedure is continued until a functioning plane, which coincides with the plane of function of the incisor teeth in protrusive occlusion, is developed

Fig. 10.



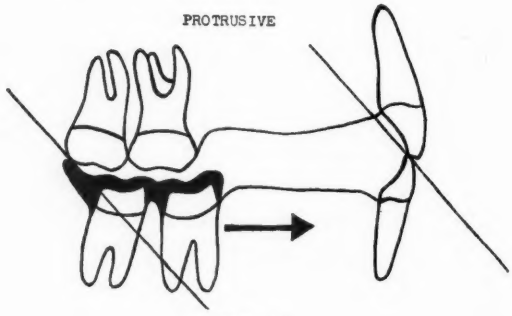


Fig. 11.

Fig. 10.—The wax patterns for the inlays and the balancing support in centric position.

Fig. 11.—The posterior balancing support is shown in a functioning position in harmony with the plane of function of the incisor teeth in protrusive occlusion.

Fig. 12.

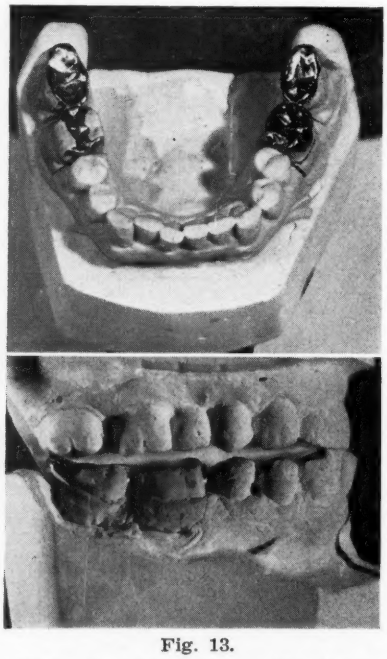


Fig. 13.

Fig. 12.—The finished castings of each side are soldered together, and in position on the master cast.

Fig. 13.—A state of equilibrium is shown existing between the forces applied on the incisor teeth and on the posterior balancing support.

in the wax pattern (Fig. 11). The part of the wax pattern where posterior balancing support is being developed should not be carved manually. The upper second molars are permitted to produce the amount and path of reduction of the wax surface that is necessary for harmonious function with the incisor teeth.

CASTING AND SOLDERING

After the wax pattern of the balancing support plane is developed, the wax patterns are removed, invested, and cast as single units. The castings are then placed in their respective cavities in the dies, the occlusion in centric and lateral occlusions is perfected, and the inlays of each side are soldered together and placed on the master cast (Fig. 12). By using articulating paper as a guide, the occlusal aspects of the posterior balancing supports are perfected to establish the approximate degree of balance desired between the incisors and the posterior balancing supports in protrusive position by grinding on the castings (Fig. 13). The final adjustment for balance between the incisor teeth and the posterior balancing supports is then accomplished in the mouth. The occlusion in centric, lateral, and protrusive positions must be checked and all remaining interferences removed to the satisfaction of the operator and the comfort of the patient. The operator may control, by equilibration, the degree of function in the incisor region. The degree of function should be determined by the relative state of health of the periodontium in the incisor region.

CONCLUSIONS

Many patients with evidence of periodontal disorder, abrasion, or discomfort in the anterior segment of the mouth have these conditions incorrectly diagnosed and treated as reduced vertical dimension. A functional analysis of the patient's occlusion may reveal that the normal arc of closure is altered by premature contacts, causing a protrusive thrust of the mandible, forcing the patient to function in an eccentric position. When this malfunction is corrected by occlusal equilibration and by providing posterior balancing support in protrusive occlusions, all traumatic factors can be eliminated. In many cases there is no need for increasing the vertical dimension by means of occlusal reconstruction, bite plates, or splints.

Radiographic and clinical evidence of continued improvement, and of the restoration of the structures supporting the incisor teeth to a state of health can be demonstrated. The technique is in harmony with basic fundamentals and can be applied with a minimum of surgical intervention, expense, and consumption of time.

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COLD CURE ACRYLIC RESIN SPLINTS IN OCCLUSAL REHABILITATION

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COLD CURE ACRYLIC resin has been a boon to dentistry and particularly those practitioners who are interested in oral rehabilitation. Temporary acrylic splints, made at the chair, are far superior in comfort, strength, esthetics, function, and retention to celluloid crown forms filled with silicate or zinc oxide and eugenol cement or to festooned aluminum crown forms filled with the zinc oxide and eugenol cement. The necessity for destroying the temporary crown on removal, the presence of inflamed gingivae around the abutments and very sensitive teeth, and the impossibility of replacing missing or extracted teeth except by laboratory procedures are all avoided by the techniques using cold cure acrylic resin.

INDICATIONS

Cold cure acrylic resin crowns or splints are indicated in the following situations:

1. To protect individual teeth after preparing them for full coverage.
2. To protect abutments for fixed bridgework which have been prepared for full coverage and to supply missing teeth.
3. To provide for the immediate replacement of extracted teeth where fixed bridgework is planned.
4. To splint periodontally involved teeth during the course of periodontal treatment.
5. To act as temporary splints to increase the occlusal vertical dimension where fixed permanent splints are to be made later.
6. To hold a gingival pack after gingivectomy, gingivoplasty, or deep curettage around teeth to be used as abutments for fixed splints. The splint also prevents the regrowth of the gingivae above the finishing line of the preparation.
7. To prevent the movement of abutment teeth where fixed bridgework is planned but cannot be inserted for a period of time up to six months.

TECHNIQUES OF CONSTRUCTION

An alginate impression of the region concerned is made and stored as the manufacturer directs. The teeth are prepared for full coverage. The preparations

Received for publication Aug. 19, 1954.

need not be complete, but sufficient tooth structure is removed to eliminate undercuts and provide space enough for sufficient thickness of acrylic for strength.

These are two possible procedures for immediate replacements. After the initial alginate impression is made, the crown of the tooth to be removed may be cut off at its gingival margin; the splint is constructed; and then the root can be removed. The alternative method is to remove the tooth, construct the splint, and grind off the portion of the acrylic resin that extends down into the tooth socket. The second procedure may be modified by covering the socket with tin foil. Either method is adequate although the first is neater.

When missing teeth are to be replaced, the block of alginate between the impressions of the abutment teeth is removed. This allows the plastic to flow into the space where the missing teeth should be. The crude block of plastic can be carved to the shape of teeth before the splint is inserted.

Another method is to set up the missing teeth in wax on the study cast, make an impression of the cast in alginate, prepare the abutment teeth in the mouth, and insert the impression filled with plastic back into the mouth. A variation is to insert the waxed-up teeth in the mouth prior to making the alginate impression.

When the preparation of the abutments has been completed sufficiently to receive a splint and the alginate impression is at hand, the undercuts in the alginate impression of the soft tissues are removed. The impressions of the gingival margins of the abutment teeth are trimmed away. This allows for easy reinsertion of the impression into the mouth and for adequate thickness of acrylic resin at the gingival margins of the abutments. The alginate in the interproximal spaces is removed from the entire region for which the splint is intended.

A sufficient quantity of cold cure acrylic resin to fill the spaces in the alginate impression for the abutments and missing teeth is mixed. It should have a medium consistency—neither creamy nor puttylike. There must be no trace of eugenol in the mixing jar or on the spatula as this will prevent the acrylic resin from setting. The material is inserted into the impression with a thin instrument in such a way as to avoid the formation of air bubbles.

The abutment teeth are moistened, and the alginate impression with the acrylic resin in it is reseated in the mouth over the *wet teeth.* It is allowed to remain in position for three to five minutes. The fact that the teeth are wet aids in the removal of the splint and helps prevent damage to the pulps by the heat of the setting of the acrylic resin. The impression is removed with a snap. If the splint is distorted, it is readapted to the teeth and teased off after the resin starts to harden. If the splint remains on the teeth, it is teased off carefully and readapted once or twice before the final set.

Occasionally, the acrylic resin will warp in setting; and after the final hardening takes place, the splint will not seat. This can be remedied by grinding out the inside of the crowns, drilling a hole in the occlusal surface of each one, filling the crowns with a thin mix of acrylic resin, and seating the splint in the mouth for three to five minutes.

The margins of the splint should be trimmed carefully, and the interproximal spaces should be relieved to allow for proper hygiene and to prevent irritation of the gingival tissues. If there are missing teeth, the pontics are shaped with stones and discs. The occlusion is balanced carefully, particularly to prevent excess biting pressure on the splint. This is very important in order to prevent breakage. All short margins, discrepancies, air bubbles, imperfections, and thin spots can be remedied by the Nealon brush technique. The splint is cemented in place with zinc oxide eugenol resin cement.

In order to achieve satisfactory results with these splints, the technique must be followed carefully. A few extra minutes used in adding to the margins, trimming, and polishing will make a tremendous difference in their comfort and function. These splints may be worn in comfort for from six months to a year.

ADVANTAGES OF ACRYLIC RESIN SPLINTS

Cold cure acrylic resin splints can be made easily and quickly at the chair. This reduces the time and expense to both the patient and the dentist. The margins can be finished nicely, and the occlusion can be balanced satisfactorily. The embrasures can be made open to allow the maintenance of good oral hygiene by the use of a rubber stimulator. Patients are comfortable wearing them and are prepared psychologically for the subsequent permanent splint. Any abutment tooth that can be used for permanent splinting can be covered with a temporary acrylic resin splint. This includes teeth that are short, broken down, or require posts. They are nonirritating to the gingivae and are very effective in holding a surgical pack in place when gingivectomy or gingivoplasty is done in conjunction with the preparation of the abutments, as suggested by Roper.[1] An added value is that the splint will maintain the positions of the abutments, and prevent their drifting and the subsequent difficulty of insertion of the permanent splint.

The esthetics can be quite good depending on the skill and care of the operator. The original size and shape of the teeth can be reproduced. When used as immediate replacements, the tissue-borne surface can be relined easily. If breakage occurs, the splint can be repaired by the Nealon brush technique, or it can be replaced by making an impression of the region with the old splint in place and making a new splint. In severe periodontal conditions where permanent splinting is indicated later, the loose teeth can be splinted with a temporary acrylic resin splint during the course of periodontal treatment. In patients with collapsed occlusions where the vertical dimension is to be opened subsequently with permanent splints, the occlusion can be built up to any desired level with temporary acrylic splints so that the patient's tolerance to the new occlusion can be observed before the dentist is committed by permanent splints.

DISADVANTAGES

This material has some disadvantages, but they are mostly minor. The porosity of the acrylic resin is more than if it is packed in a mold and processed. A certain amount of occlusal wear can be observed. The color is not fast and

generally darkens over a period of time, particularly since the material shows an affinity for cigarette smoke, foods, and chewing gum. None of these objectionable qualities, however, are serious enough to lessen the uses of the material and technique.

OTHER USES

To use these splints in conjunction with a surgical pack after gingivectomy or gingivoplasty around the abutment teeth, the temporary crowns are overfilled with a zinc oxide eugenol rosin pack. When the splint is inserted, the excess material will squeeze out over the adjacent gingivae. The material is adapted to the area of the surgery with a wet pellet of cotton held in a tweezer. To remove the splint at subsequent visits, it is teased off carefully with an instrument, or removed with a child size surgical forceps. The cement must be cleaned out of the crowns carefully before the splint is recemented. The splint must never be reinserted without cleaning and recementation, or leakage of saliva and food into the crowns will cause subsequent sensitivity of the teeth.

SUMMARY

Cold cure acrylic resin splints can be used in a variety of situations met in the course of occlusal rehabilitation. They can be used to protect abutments, to provide immediate replacements, to splint periodontally involved teeth, to test the patient's tolerance to a new occlusal level, to hold gingival packs, and to prevent the movement of abutment teeth. They have a number of advantages over other methods, and few disadvantages.

I wish to thank Dr. Leo H. Roper for his suggestions and help in the preparation of this article.

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INCREASED HANDPIECE SPEEDS IN RESTORATIVE DENTISTRY

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MODERN RESTORATIVE dentistry has developed as a result of improvements in both dental materials and dental techniques. The most recent of the technical advances touches upon what is probably the basis of restorative dentistry—tooth preparation. The introduction of increased handpiece speeds holds out much promise for operative procedures which will be less traumatic to the patient and less enervating to the dentist.

Effective cutting with abrasives depends upon the surface speed of the instrument.[1] This seems also to hold true in regard to cutters, yet the mainstay of operative dentistry has been the dental burr used at speeds below 5,000 r.p.m. Under these conditions, hand pressure in excess of half a pound is required before the burr actually begins to cut. This makes control of the instrument difficult and causes overheating.

Any increase in rim speed results in a noticeable improvement in cutting ability and a marked reduction in the hand pressure required. The effect of increasing the rotational speed of the handpiece on the resulting rim speed of the instruments of various diameters is shown in Table I.

TABLE I. APPROXIMATE SURFACE SPEED IN FEET PER MINUTE

DIAMETER OF INSTRUMENT (INCH)	6,000 R.P.M.	20,000 R.P.M.	36,000 R.P.M.	72,000 R.P.M.
1	1,570	5,233	9,420	18,840
1/2	785	2,617	4,710	9,420
1/4	392	1,308	2,355	4,710
1/8	196	654	1,177	2,355
3/32	138	490	897	1,794

Optimum speeds with diamond instruments probably lie between 5,000 and 9,000 surface feet per minute.[1] A one-inch disk must turn nearly 20,000 r.p.m. to attain a rim speed of 5,000 feet per minute. Since most preparations are made with instruments having diameters of less than ⅜ inch, the rotational speeds required to bring the surface speed of these cutting instruments into the optimum range can be found in Table II.

Most A.C. dental engines in present use can be made, by means of simple electrical changes and a high-speed drive pulley, to turn specially designed handpieces at speeds approximating 20,000 r.p.m.[2] In the contra-angle handpieces,

Received for publication July 8, 1954. Revised by the author Oct. 6, 1954.

TABLE II. ROTATIONAL SPEED REQUIRED WITH INSTRUMENTS OF VARIOUS DIAMETERS TO OBTAIN A SURFACE SPEED OF 5,000 FEET PER MINUTE

DIAMETER OF INSTRUMENT (INCH)	R.P.M.
1	18,840
1/2	37,680
1/4	75,360
1/8	150,720
3/32	200,960

gear losses and the resulting heat make it more difficult to attain high speed. The operator should have several contra-angle handpieces available if he is to make the best use of higher speeds. It has been established that heat is the main cause of discomfort and possible pulp damage during operative procedures. Regardless of speed, a coolant stream should be applied to the cutting instrument whenever it is in contact with the tooth. Vibration is another major cause of discomfort to the patient. It can be minimized by careful selection of diamond instruments and careful dressing of Carborundum stones.[3, 7]

Disks running at efficient cutting speeds make thinner, smoother cuts than when they are subjected to heavy pressure at low speeds. They also have practically no tendency to bind or pull.

PRECAUTIONS

Accelerated speed calls for some precautions. The belt must be quite slack so as to avoid unnecessary friction on bearings, permit maximum speed to be attained, and provide a safety factor in case a contra-angle handpiece should jam. The pitch of the sound produced by the engine, belt, and handpiece soon serves as a guide in adjusting the belt tension for maximum speed. Speed should be checked occasionally by means of a tachometer or revolution counter. It is important to permit the instrument to reach maximum speed before beginning to cut. Hand pressure should never be great enough to reduce the speed of the instrument.

Proper cleaning, lubrication, and care of instruments and equipment is of the utmost importance in maintaining uniform high speeds. The cleaning and lubrication of contra-angle handpieces in particular must be frequent and thorough if overheating and binding are to be minimized.

Speeds in excess of 20,000 r.p.m. can now be used routinely. A means of switching to lower speeds for prophylaxis and polishing is desirable and easily provided.[2] These speeds seem to indicate a trend toward much higher rotational speeds resulting in far more efficient surface speeds for instruments of small diameter. The work of Nelson, at the Bureau of Standards,[4] and Page[5] indicate some of the possibilities inherent in rotational speeds of 60,000 to 100,000 r.p.m.

SUMMARY

High surface speed with diamond, Carborundum, or tungsten carbide instruments is an efficient means of removing tooth structure. A continuous coolant

stream carries the heat away, resulting in far less discomfort.[3, 6, 7] The coolant improves visibility and minimizes clogging of the instrument by flushing away debris. The efficiency of the cutting tool operating at high speed makes pressure not only unnecessary but useless. The handpiece or contra-angle can be handled as delicately as a fine pen. The lack of necessity for pressure permits the operator much better control. This reduces his fatigue and makes the dental procedure briefer and more tolerable to the patient. Clinical results thus far indicate that the possibilities for damage to the tooth or soft tissue are reduced.[3] The impression gained from clinical trial is that the patient is less tense, and the operator himself is more relaxed. The reduction in time required to complete preparations is an obvious advantage. Increasing the speed of the cutting tool is a recent development in restorative dentistry which deserves more complete trial and investigation.

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THE PROSTHODONTIST'S ROLE IN CRANIOPLASTY

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THE NUMBER OF PATIENTS requiring cranioplasty has increased considerably in recent years, due to the large number of cranial injuries occurring in this modern age and the increased ability of modern medicine to treat such injuries. Patients with severe head injuries continue to live, due primarily to improved surgical techniques, antibiotics, the increased use of whole blood, and improved methods of anesthesia. The new front-line neurosurgical teams and rapid evacuation of casualties via helicopter are added factors in war injury cases. These patients in many instances require calvarium plates in order to restore their normal appearance and permit their living normal daily lives, in addition to providing the required protective covering to the brain.

MATERIALS USED FOR CALVARIUM PLATES

Various types of materials are commonly used for calvarium plates. All have advantages and disadvantages. Formerly, metals of different kinds, from gold and tantalum to stainless steel alloys, were used almost exclusively to repair calvarium defects. Most of these metals possessed the advantage of being strong, could be made thin, and were fairly easily fabricated and attached as an onlay to the bone surrounding the skull defect. All of the metals have the disadvantage of conducting heat and cold too readily. Probably as a result of this, the tissues do not tolerate even the most desirable metals as well as formerly thought, and many calvarium plates have had to be removed after a period of years. Metal has the further disadvantage of interfering with postoperative roentgenographic examination.

The trend today is toward the use of plastics, of one type or another, for calvarium plates. Polyethelene and methyl methacrylate are the ones most commonly used at present. They are kind to the tissues and are poor conductors of heat and cold. They present some difficulties in their fabrication, insertion, and application to different-sized openings in different areas.

Polyethelene is obtainable in sheets of varying thickness. The sheets can be sterilized, easily contoured after immersion in hot water, and then cut to size, adapted, and secured to the bone surrounding the defect during the operation. It is not entirely satisfactory for extensive openings in the calvarium, or for use where variations in thickness are essential to restore certain lost skull contours

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The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

Read before the American Denture Society in Chicago, Feb. 6, 1954.

Received for publication Feb. 18, 1954.

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such as the supraorbital ridge. Rubin,[1] in a three-year study, found polyethelene to be compatible to the tissues provided the pure form was used. Polyethelene compounded with additional agents for various commercial uses produced undesirable tissue reactions, such as edema, hyperemia, fibroblastic proliferation, and lymphocytic and eosinophilic infiltration. Alexander and Dillard[2] used polyethelene extensively in sheet form, 3.25 mm. in thickness.

Both the regular and room-temperature cure methyl methacrylate resins are used for calvarium plates. The latter has a distinct advantage in that it can be formed to fit the opening in the skull, sterilized, cured, and inserted during the single cranioplasty operation. A mix of room-temperature cure acrylic resin is placed in a sterile, pliable plastic bag, rolled out into a sheet, like cookie dough, and adapted directly to the beveled periphery of the opening in the skull. It is then carefully removed, trimmed, both sterilized and cured by autoclaving for twenty minutes, and inserted. Unfortunately, room-temperature cure acrylic resins contain teritary amines and other additives, which may produce unfavorable tissue reactions. Also, when cured in an autoclave, outside of a pressure mold, the plate is pitted, porous, and weaker than properly processed regular methyl methacrylate.

Regular methyl methacrylate resin appears, at this time, to be the most desirable material to use for the construction of large calvarium plates. Its kindness to the tissues has been fairly well established, and it is neither carcinogenic nor epileptogenic. Several cases are known in which methyl methacrylate calvarium plates have been in place for at least five years, with no apparent undesirable tissue reaction. Calvarium plates made of this material are strong, resilient, and can be easily made and adapted to practically any opening in a manner that assures the restoration of the exact contours of the lost portion of the skull.

From the surgeon's standpoint, methyl methacrylate calvarium plates have the disadvantage of being difficult to fabricate accurately enough to assure proper adaptation to the periphery of the opening without undue difficulty. This one important disadvantage of methyl methacrylate can be readily overcome by employing the services of a prosthodontist who understands the fabrication of the calvarium plate, and can, through the use of dental instruments, greatly simplify its proper adaptation and insertion. This highly desirable cooperative effort results in great benefit to patients requiring cranioplasty and to a simplification of the operation compared to the use of polyethelene. It also opens a new field for the prosthodontist, in which he can render a very worth-while health service.

Trapozzano,[3] in the late forties developed a technique for the fabrication of methyl methacrylate onlay type of calvarium plates. Friedrick[4] and others have contributed to the improvement of the technique, and a more desirable inlay type of plate has evolved. However, in all known techniques the fabricated inlay type of plate is turned over to the surgeon for insertion. Fitting of the plate is accomplished by the surgeon trimming the periphery of the skull opening to fit the plate, which cannot be made to fit perfectly in advance due to the difference in circumference of the bone and that of the outside of its variable soft tissue cover-

ing. This procedure often results in extensive, unnecessary bone loss, is time consuming, and the resultant fit is not generally satisfactory.

The chief of surgery at the U. S. Naval Hospital, Great Lakes, Illinois, recognized the fact that the prosthodontist should be able more easily and accurately to adapt the plate he has fabricated by adjusting the plate to fit the bone. Following through on this idea, and employing the services of the prosthodontist to the fullest extent has resulted in a reduction of about two hours in operating time for the average operation. It has also resulted in better-fitting plates.

Fig. 1.—Indelible pencil line drawn around margin of defect ⅛ inch inside of the place where the peripheral bone begins to round inward.

TECHNIQUE OF CRANIOPLASTY

The procedure for cranioplasty employed at this hospital is as follows: The patient's hair is clipped to expose the defect and approximately 1 inch of the surrounding scalp. The margin of the defect is determined by palpation and with the aid of roentgenograms. An indelible pencil line is drawn around the margin ⅛ inch inside of the place where the peripheral bone begins to round off into the defect (Fig. 1). A strip of black boxing wax is softened and the edge of the strip adapted to the scalp about 1 inch outside the periphery of the defect. The wax is adapted closely, in all of the scalp contours, to serve as a retaining dam for the impression material. Hydrocolloid impression material, which has been thoroughly softened and permitted to cool to near its hardening point, is poured over the scalp within the wax to a depth of approximately ½ inch. A small sheet of gauze is dipped in ice water, squeezed slightly to remove excess water, and spread over the hydrocolloid. A layer of quick-setting plaster is then placed over the gauze, to back up and stabilize the impression. When the plaster has set, the entire impression, with the wax retaining dam, is removed. The indelible

pencil outline on the skull will have been transferred to the hydrocolloid of the impression. The transferred outline is accentuated by being retraced with an indelible pencil. The impression is then poured immediately in stone, and separated as soon as the stone has set sufficently to assure a good cast. Upon separation, the outline of the defect will be found to have been transferred again to the cast. A second line is immediately drawn ⅛ inch outside the entire indelible pencil outline (Fig. 2). Before the stone sets completely, a knife cut is made at right angles to the surface of the cast along the entire inner indelible outline to a depth

Fig. 2.

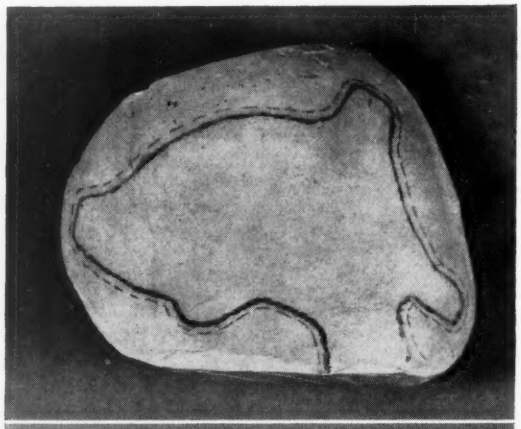

Fig. 3.

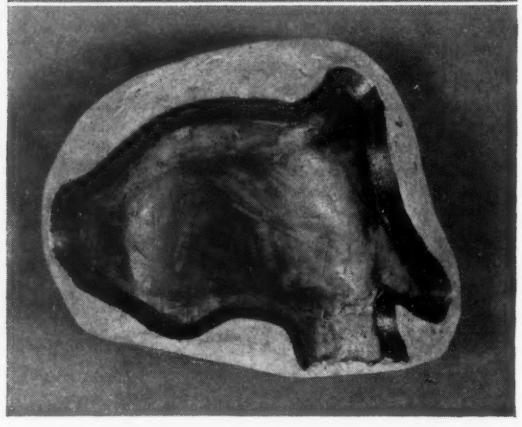

Fig. 2.—Stone cast made from a hydrocolloid impression of defect. The inner solid line is an indelible pencil outline which was transferred from the impression to cast. The broken line drawn ⅛ inch outside the solid line marks the ultimate outer margin of the calvarium plate.

Fig. 3.—Stone cast showing the excavated area and the peripheral bevel.

of ¼ inch. All of the stone to a depth of ¼ inch is then removed from the area within the original cut. The sides of the excavated area are then tapered, by cutting from the periphery of the base of the excavated area to the outer outline on the cast (Fig. 3). The entire excavated area is filled with wax, and shaped so as to properly restore the defective area of the skull to its original form (Fig. 4).

The cast, with wax, is invested in a suitable flask, and the calvarium plate is processed in clear methyl methacrylate against tin foil, in the same manner as in processing a denture. In order to assure obtaining a calvarium plate that does not contain additives which might be injurious to the tissues, it is desirable to use methyl methacrylate polymer of excellent quality and freshly distilled monomer.

Fig. 4.

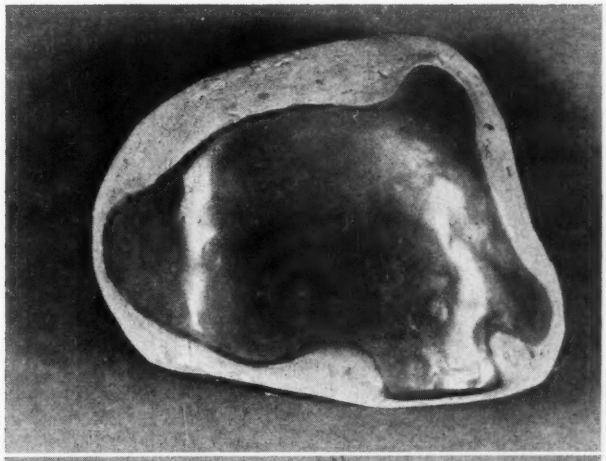

Fig. 5.

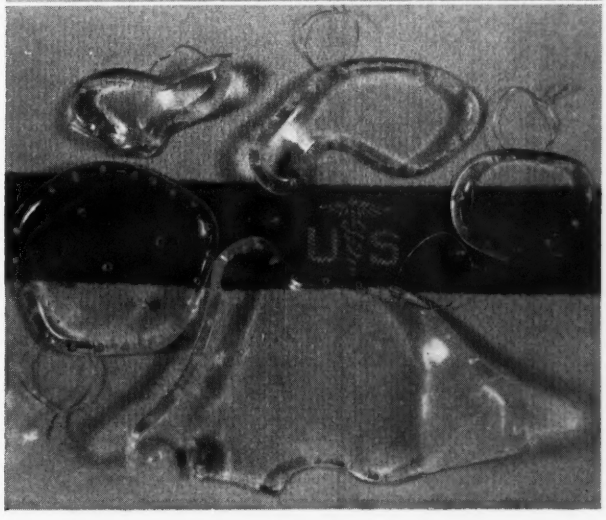

Fig. 4.—Excavated area of the cast filled with wax, which is contoured to restore the shape of the lost portion of the skull.

Fig. 5.—Methyl methacrylate calvarium plates of various shapes and sizes. Note the holes in the beveled margins and the wire finger loops to assure against dropping the plate during the operation.

The processed calvarium plate is trimmed to the exact contour and thickness desired, without altering the angle of the peripheral bevel. After trimming, the contour of both the inner and the outer surfaces of the plate should simulate the normal contour of the skull in the area of the defect. It should also compare in

thickness with the thickness of an average denuded skull. When properly shaped, the calvarium plate is highly polished. Holes are then placed around the beveled margin of the plate with a No. 4 round bur. The holes are drilled from the beveled side of the plate, approximately ½ inch apart. They are placed immediately outside of the inner margin of the bevel and directed outward at approximately a right angle to the beveled surface (Fig. 5). To prevent the sharp margins of the holes from cutting the sutures, later used in its insertion, it is necessary that the holes be countersunk on both the inner and outer surface. This is best accomplished with a dull flame-shaped vulcanite bur.

Two calvarium plates are made routinely for each patient. One is finished to the size of the stone cast. The second is fitted on the patient and trimmed to the exact size, estimated as accurately as possible by further palpation of the margin of the defect (Fig. 6). This provides an additional plate in case the most accurately fitted plate proves too small, or a plate is accidentally dropped, or becomes otherwise contaminated during the operation. When entirely completed, a finger loop of 0.018 inch stainless steel wire is placed in one of the holes to facilitate holding the plate if it becomes slippery with blood during the operation. (Fig. 5). The plates are sterilized in Zephiran Chloride for at least eighteen hours prior to the operation.

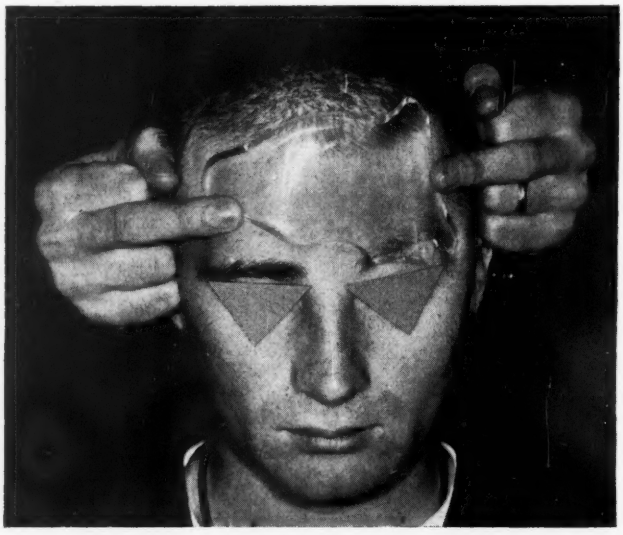

Fig. 6.—The calvarium plate fitted on the patient prior to the operation to as near the exact size as possible.

INSERTION OF THE CALVARIUM PLATE

The operation for the insertion of the calvarium plate is accomplished by the surgeon and prosthodontist working as a team. The surgeon prepares the flap and exposes the bone immediately surrounding the defect. The prosthodontist then bevels the periphery of the defect and applies bone wax as needed to reduce excessive bleeding. The calvarium plate is then tried in place. Slight pressure is exerted upon the plate, and any high areas are noted through the plate by the

Fig. 7.

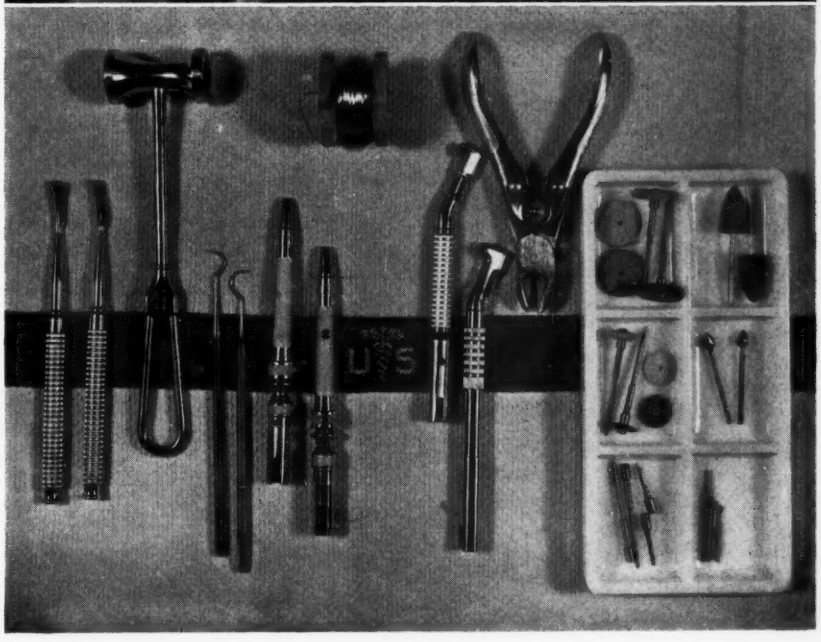

Fig. 8.

Fig. 7.—Beveled margin of the plate being polished during the operation after final fitting. Note the sterile sleeve over the dental engine arm. Large plastic disks are attached outside of each engine arm pulley (inside the sleeve) to prevent the sleeve from catching in the engine belt.

Fig. 8.—The instruments required by the prosthodontist in performing his portion of the operation. A dental engine and sterile sleeve are also required.

blanching which occurs from displacement of the free blood which is always present. The high areas are marked on the outside of the plate. The plate is removed and the bevel trimmed as indicated with CCC trimmers and vulcanite burs. This procedure is repeated until an accurate fit of the plate to the beveled margin of the bone is obtained. The beveled margin of the plate is then polished with pumice incorporated rubber wheels wherever it is necessary to alter the original polish (Fig. 7). The plate is then returned to place in the skull, and a slight mark is placed in the bone and plate with a No. 40 bone bur in a contra-angle hand piece, opposite the holes in the plate selected for the insertion of wires for its retention. The wire loop is removed from the plate, and the plate is turned over to the surgical nurse for the insertion of No. 00 silk sutures in each hole not marked for wires.

With the No. 40 bone bur in a contra-angle hand piece, holes are drilled through the outer table into the diploe layer of the bone at the points previously marked. An additional hole is then drilled into the diploe layer so as to contact each of the former holes at right angles. Stainless steel wire, 0.018 inch, is then placed in each of the holes, completing the prosthodontist's portion of the operation.

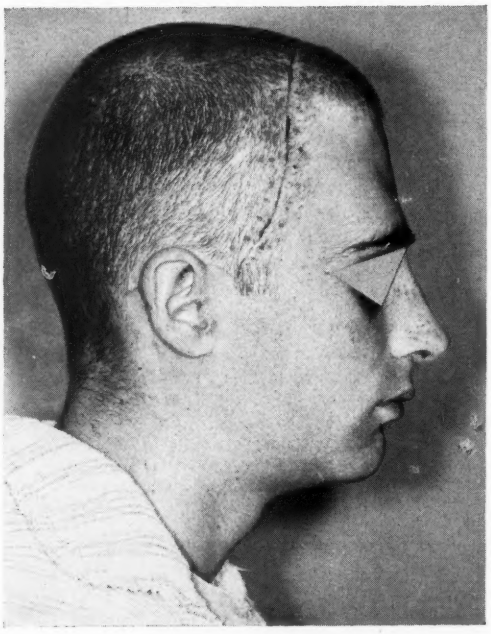

Fig. 9.—Lateral view of patient following operation.

The plate is put in place and secured to the bone by the surgeon by means of the wires. The No. 00 silk suture in the remaining holes is used to pull and hold the pericranium over the periphery of the plate. The flap is returned and sutured, and the operation is completed.

It is the prosthodontist's responsibility to make sure that the sterile instruments he needs for performing his portion of the operation are at hand. These are:

portable dental engine with wrist joint and sterile sleeve (Fig. 7), bone chisel with a wide, curved head for beveling bone, hand mallet, No. 23 curved explorer, straight hand piece, contra-angle hand piece, wire cutter, mandrel for straight- and contra-angle hand piece, No. 4 round bur, No. 40 surgical bur, Burlew disk, flame-shaped vulcanite bur, small Cratex wheel for mandrel, large CCC trimmer, 0.018 inch stainless steel wire (Fig. 8). All of the foregoing items should be sterilized at least in duplicate, to provide for unforeseen contingencies during operation.

Patients with various types of injuries requiring calvarium plates have been admitted to this hospital. During hostilities in Korea, there were as many as 6 admitted in one month.

The most unusual and difficult case of this type was that of W. G. This patient, a 21-year-old hospital corpsman, was hit in the left temporal region by a mortar shell while serving with the Marines in Korea. The left eye, the supraorbital ridge, a large portion of the forehead, and frontal lobes of the brain were torn away. Thanks to his rapid transfer to a hospital ship via helicopter, and the excellent capabilities of the medical officer who provided the emergency surgical treatment, his life was saved. His I.Q. and mental reactions, except for certain personality changes, were normal. However, his appearance was unsightly (Fig. 1), and it was necessary to attempt to restore his appearance to an acceptable degree to permit his living a normal daily life. A methyl methacrylate calvarium plate, approximately 4 by 7 inches, shaped to conform to the margins of the defect and restore the lost bony contours of the skull, was made and inserted. The supraorbital ridge and roof of the left orbital fossa were restored in a manner that facilitates the construction and retention of an artificial eye. The appearance of the patient several days after operation is shown (Fig. 9). As has been the case in all patients treated via cranioplasty, he was able to get out of bed the next morning, experienced very little pain, and made a general rapid recovery from the operation.

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U.S. NAVAL HOSPITAL
GREAT LAKES, ILL.

TRICHLOROETHYLENE ANALGESIA

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Brunswick, Ga.

ALMOST SINCE THE first painful symptoms of operations were recorded, countless methods to alleviate this pain have been tried. Even as far back as the ancient Egyptians, their inscriptions indicate that they inhaled the fumes of hemp or hashish to produce artificial sleep.

Mandrake, as a narcotic, is mentioned in the Bible and was known to the Babylonians and Hebrews. Opium was used as far as back as the early Greeks and Chinese.

These soporifics, including alcohol, were gradually discarded in surgery for the more humane technique of speed, and operations were performed only as a result of dire necessity. Surgery progressed much faster than the art of anesthesiology. Our grandfathers were the first to receive painless surgery.

It was little more than a century ago that modern inhalation anesthesia was introduced. Since that time many changes and improvements have been made, both in the drugs employed and their method of application. The methods in use today are quite a change from a sponge soaked in the anesthetic and applied to the patient's nose.

Trichloroethylene, a liquid exhibiting anesthetic qualities, first came into use as a commercial solvent about the middle of the last century. Addiction of workers to this solvent was fairly common, but the pleasant symptoms they received were often followed by violent nausea, optic neuritis, and various palsies. These untoward symptoms were found to be the result of impurities in the solvent.

In the twenties this solution was purified, and since that time it has been used experimentally and clinically in this country, and more especially in Great Britain and Canada.

USE IN TRIGEMINAL NEURALGIA

About 1940, its effectiveness for reducing the spasms of trigeminal neuralgia was brought to our attention. With the simplest instruction a patient can relieve himself of the acute, excruciating symptoms of a sudden attack of trigeminal neuralgia.

The drug can be prescribed in ampule form, or can be dispensed by the druggist in one or two ounce dark-colored bottles. Larger sized vials may be obtained. When pain strikes suddenly, the patient may pour a small amount of the drug into a small piece of linen and, *while sitting up, not lying down,* inhale the fumes until relief is felt. If the patient relaxes, he will drop the contained drug. This point should be emphasized to him.

Read before the American Academy of Restorative Dentistry, Chicago, Ill., Feb. 7, 1954.
Received for publication Aug. 23, 1954.

USE IN OPERATIVE DENTISTRY

Trichloroethylene has lately come into wide use in obstetrical work and as an analgesic in operative dentistry.

What are the qualities we are looking for in an anesthetic? Of course, the nicest thing we could hope for would be an inexpensive substance which could be applied to the part, and produce an immediate cessation of sensitivity. When we are through operating, another substance would give immediate normal sensation again. This should be accomplished with no psychic trauma, side reactions, or complications. No such simple obtunding or anesthetic substance is available at this time.

TRICHLOROETHYLENE

A drug which approaches this ideal is trichloroethylene when used for an inhalation analgesia in operative dentistry.

The drug, now produced in U.S.P. concentrations, is a clear, colorless liquid, a cross between chloroform and ethylene. For all practical purposes, it is non-explosive and noninflammable. It is stabilized with 0.01 per cent thymol, and it should be stored in closed, colored containers to exclude light.

In the concentrations used in this technique, the drug is nonirritating to the respiratory tract and is nonviscerotoxic. It does not change the blood chemistry, and any cardiac irregularities (tachycardia, brachycardia, arrhythmias) are due to overdosage or too rapid induction, for which there is no excuse. In more than 300 applications, there has been no cyanosis, nausea, or other untoward symptoms observed in our office.

SAFETY FACTORS

The safety factor of this application cannot be overemphasized if it is used intelligently. It seems to be safer than any of the popular inhalation anesthetics.

If the patient is carried into the anesthetic (instead of the analgesic) planes, the safety factor rapidly goes down. Like any other general anesthetic, it is, in the last analysis, a voluntary poison and can cause death. Our oxygen cylinder, for use in emergencies, has not been disturbed.

The only contraindications for its analgesic use are an active cardiac condition or a toxic pregnancy. It has been suggested that if a local anesthetic is used in conjunction with this analgesia, a solution containing a synthetic constructing agent be used, such as Neo-Synephrine or Cobefrin. We have observed no untoward symptoms, however, when we have used Xylocaine, 2 per cent with epinephrine 1 :100,000 in 47 cases.

ANALGESIA

Analgesia is the first plane or phase of anesthesia which may be termed sub-anesthesia. With trichloroethylene inhalation, this plane is reached quickly and smoothly. At first there is a brain stimulation with a flow of ideas. This is followed quickly by a feeling of warmth and well-being. As one goes deeper toward

anesthesia, memory is lost and, though a patient may experience some pain and complain about it at the time, he will not remember it. Soon there is a tingling of the extremities, a weakness of the knees, and some signs of muscular incoordination. Speech is usually slow, and the voice becomes thick or guttural. The sense of pain is progressively obtunded, and operative procedures can be carried on without objection by the patient.

What can be accomplished in this subanesthetic stage depends to a large extent on the susceptibility of the patient to the drug. It is suggested that a simple cavity preparation be done when the patient first experiences this analgesia. On good subjects, almost any operative work can be accomplished without objection. Removal of deciduous teeth, suturing, lancing abscesses, and particularly subgingival curettage may be done, as well as operative dentistry.

Extensive work has been accomplished, necessitating ninety minutes of analgesic duration. Although no ill effects were noted, it does not seem necessary or advisable for such lengthy procedures in the dental office. In obstetrical work, this time factor has been increased many times.

No selection of patients has been attempted. When it was felt that analgesia was suited to a case, it was used, often with excellent results, generally with good results, but at times it was discarded because results were poor. Although applications are made on a trial and error basis, indications are that a more satisfactory working plane is obtained in the robust, healthy person than in the small, wiry patient. The nonsmoker may be preferable to the smoker. Age and sex apparently to make no difference, nor does the degree of apprehension. Some of the most appreciative patients seemingly are the most highly irritable ones. It appears ineffective on alcoholics and morons.

ARMAMENTARIUM

All parts of the armamentarium can be obtained from a dental or medical supply house except the last three on the list in Fig. 1.

Part *G*, the handle for hanging the canister, can be made in one of two ways. The simplest method is to bend a wire coat hanger (Fig. 1, *G-1*) or a piece of stainless steel wire, so that the canister will slide into the loop formed at the bottom, and make a hook at the top part of the wire as shown in the diagram. By this means the canister can easily be hung into place when needed.

A more stable and neat-appearing clamp can be made with a ½ inch stainless steel band bent to form a sleeve into which the canister will slide. The remaining part can be formed to clamp around the neck of the cup receptacle (Fig. 1, *G-2*), or can be screwed to the unit (Fig. 1, *G-3*). The sleeve is bent so the canister can be easily slipped out, but the other end of the strap is bent so that it is secure to the unit.

Fig. 1.—The armamentarium (except the trichloroethylene) necessary for effective yet inexpensive analgesia. *B*, Two No. 8 one-hole rubber stoppers; *C*, 12 foot rool of 2 inch gauze bandage; *D*, one 6 foot length of ¼ inch latex tubing (cut in two parts to suit); *E*, one small C-clamp; *F*, two 3 inch lengths of ¼ inch glass tubing; *G*, one handle to hold canister; *H*, one adapter to connect to air syringe; and *I*, one 4 inch flanged, chrome-plated sink coupler.

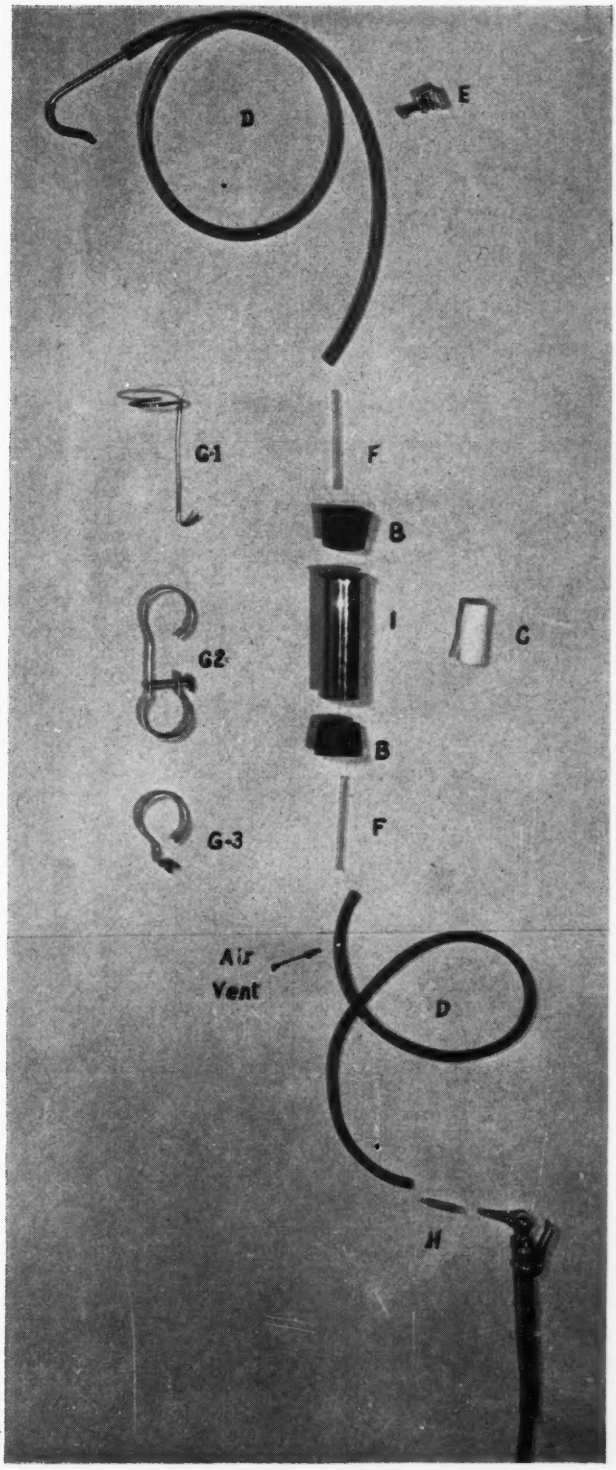

Fig. 1.—*(For legend see opposite page.)*

If an adapter (Fig. 1, *H*) is needed, it may be obtained at your local hospital. Get a used transfusion or clysis bottle. On each one there is a plastic part which acts as a connecting piece between the needle and the plastic tubing. This part, with the ⅛ inch rubber tubing left on it, makes a nice adapter with which to connect the ¼ inch rubber tubing to a Ritter or Weber air cutoff when the tip is removed from the cutoff. With the S. S. White unit, the latex tubing, can be fitted on the air cutoff very easily without an adapter.

The sink coupler (Fig. 1, *I*) is available from a plumber for about fifty cents.

Fit all parts together as shown in the diagram (Fig. 1). With a 702 bur, cut a hole into the wall of the lower tubing just below the glass tubing. This acts as an escape valve if the air pressure builds up. If a rubber stopper blows out of the canister when air pressure is on, the escape hole is too small.

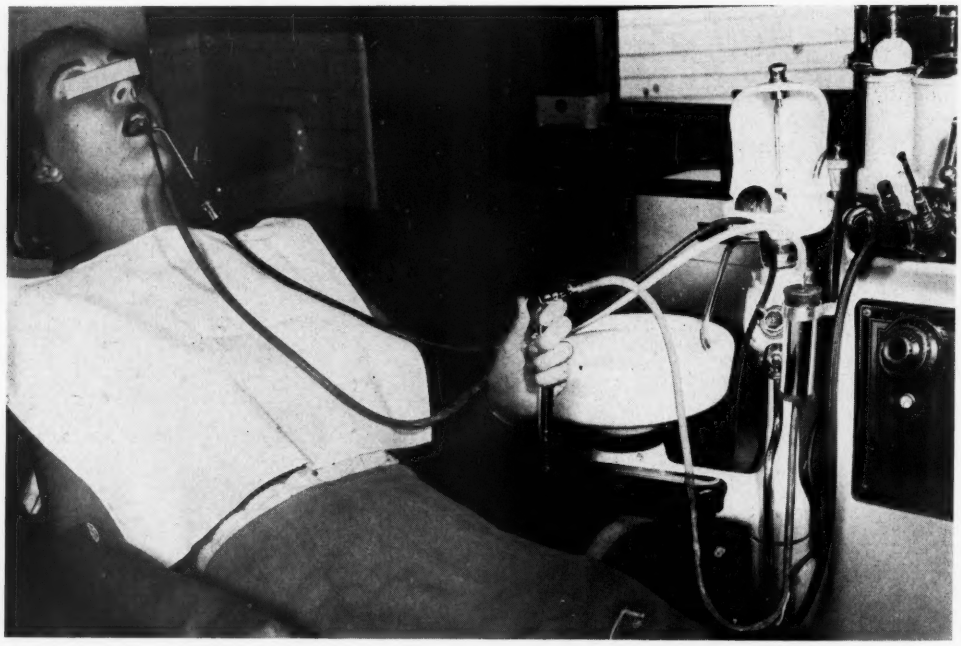

Fig. 2.—The apparatus fitted together and ready for use.

TEST PROCEDURE

Remove the upper stopper and pour about 30 c.c. (2 tablespoonfuls) of the anesthetic solution into the canister. Subsequently, 15 c.c. (1 tablespoonful) is enough, if the gauze is damp, for about one-half hour of average use. The rapidity with which the solution is dissippated is proportional to the amount of air flowing through it. The more the air flows, the faster the solution is consumed.

Insert the saliva ejector into the upper tubing and the air cutoff into the lower end, with the adapter if needed, and try the drug out on yourself. Insert the canister into the hanger. The setup should now appear as in Fig. 2. Leave

the C-clamp loose. Insert the saliva ejector (preferably the spring type) into your mouth, breathe through the mouth, and gradually increase the flow of air through the canister. If there is irritation, you are using too much gas; you should close the C-clamp to a point where there will be an adequate but not an irritating amount of gas going to the mouth when the air syringe handle is fully depressed.

Thoroughly familiarize yourself with action of the gas and the analgesic effect that it gives. There is no danger of putting yourself to sleep because, if you relax, the air flow is cut off by the spring action of the air cutoff.

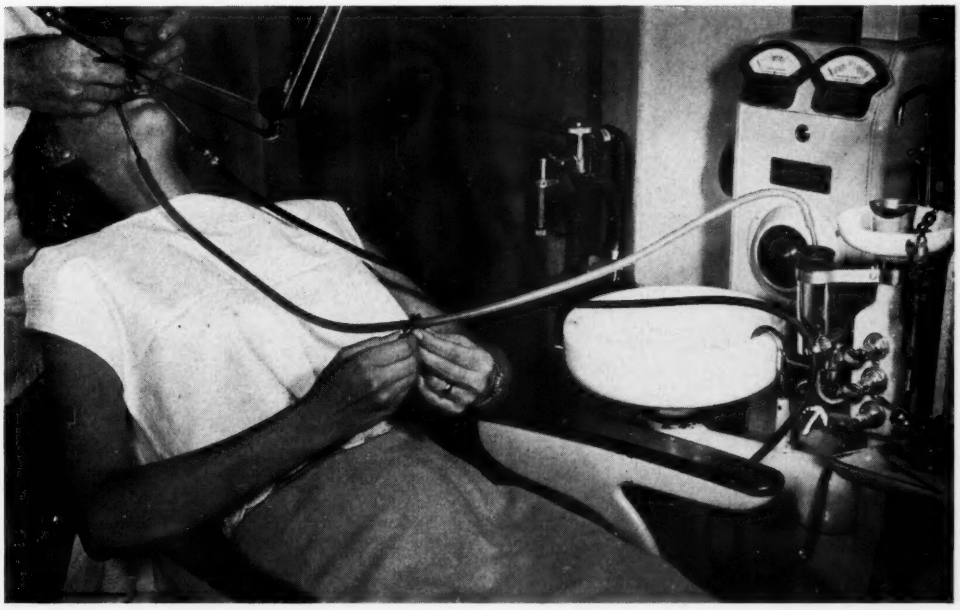

Fig. 3.—A patient controlling the mixture by means of C-clamp. Lower tubing (arrow) connects directly to the pressure side of aspirator.

USE WITH AN ASPIRATOR

A second method of flowing the air-gas mixture to the patient is by attaching the lower tubing to the outflow air vent of your aspirator. Every motor-driven aspirator has an intake (suction) and outflow (pressure) side of the pump. You merely attach the lower tube to the outflow vent by means of a suitable adapter, and you have a constant air supply when the motor is turned on. No adapter is necessary for connections to most models of Thompkins, Pilling, and Gomco aspirators.

If you prefer this method of application, set the C-clamp open to the point where the amount of gas is compatible to your nasal passages. Place the saliva ejector in the patient's mouth with the C-clamp in his hand and tell him to adjust the clamp to his satisfaction (Fig. 3). The patient will probably need some help on the first application. After that the patient knows what to expect, and

the cooperation is wonderful. When the analgesic stage is reached, tighten the C-clamp slightly in order to keep only a maintenance flow of the gas.

A very small amount (1 to 2 pounds) of air pressure is sufficient. Greater pressure tends to volatilize and lose more gas than can be consumed. This loss comes out of the patient's mouth into the face of the operator.

Premedication is unnecessary in most cases. Tolserol, 0.5 Gm. per 50 pounds of body weight, is the drug of choice, or Nembutal, ¾ gr., is helpful in some resistant cases. Seconal is not recommended as it tends to narcotize the average patient more than is necessary, and the effect lasts longer than is desirable.

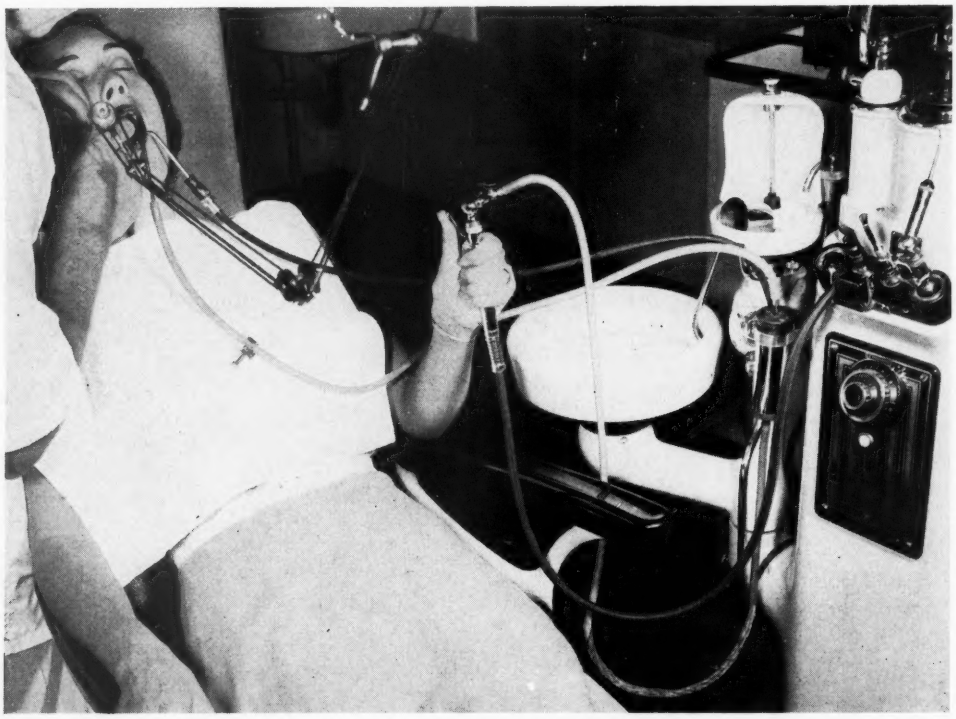

Fig. 4.—The apparatus and patient under actual working conditions. Note the C-clamp for maximum mixture, with the patient controlling the amount of air mixture.

TECHNIQUE

1. Premedicate 30 minutes before operating if necesary.
2. Have an adequate store of anesthetic solution in canister and all equipment ready to work.
3. Explain to the patient that you are not going to put him to sleep. Suggestive preparation plays an important part in a good analgesic effect. Tell him you want him to breathe, through the mouth, a gas that will leave him groggy or feeling happy.

Tell him that he is in charge of the amount of gas he is going to breathe under your supervision. If the mixture irritates his throat, tell him to cut

it down; if he is not getting enough, help him to let more of the mixture through. Let him know just what to expect, that there will be a progressively relaxing feeling, that his fingers or toes may tingle, or that his knees may feel weak. Stress the fact that he need not be afraid and, if he wants to spit, he may do so at any time. Ask him to tell you when he is ready for you to go to work.

4. Check the flow of gas under your own nostrils, and when adequate, place the saliva ejector (the spring type is preferable), and help him regulate the flow of gas. Tell him to breathe through his mouth, and count the number of inhalations. By the time he has inhaled six to ten times he should at least have a feeling of giddiness. Tell him to breathe deeply. After six to ten more inhalations he should be relaxed or have a tingling of the extremities. At this time the sensation of pain should be sufficiently obtunded to proceed with operative work. If the patient is still alert, increase the flow of gas and have him breathe deeply. After very little experience you can tell by interrogation and signs when the patient is ready.

5. Place a suction saliva ejector into the mouth and proceed with the dental operation. There is often excess salivation under this analgesia, but it can be easily aspirated.

The patient and apparatus should now appear as in Fig. 3 or Fig. 4.

After a very few applications you will have no trouble noting the signs of *analgesia.* You do not want *anesthesia.* At the first sign of complete relaxation, discontinue your air-gas mixture momentarily and get some response from the patient, i.e., get him to spit or answer questions.

The question has come up: How do you get the patient to first accept this analgesia? If you have thoroughly familiarized yourself with it and know what it will do, your assurance and confidence should allay any fears the patient might have of taking "an anesthetic" or of being "put to sleep."

Like any anesthetic, some people are resistant to trichloroethylene. It is effective on 85 per cent of the patients. If you happen to administer it to a patient of the resistant type at first, do not force enough of the gas to produce anesthesia. If 25 to 30 inhalations have no relaxing effect, you know that the patient is the resistant type. Do not think that the analgesia is ineffective generally. Discard it for that patient, and try something else.

Indications point to the fact that this technique has a definite place in the armamentarium of the general practitioner. It is not a substitute for local or general anesthesia. It is, however, a simple, inexpensive, and generally effective way to alleviate, or at least minimize, the discomfort of operative dentistry. It is so simple that your assistant can, after a little practice, prepare the patient and have him ready for the operative procedure when you are. You will be surprised at the pleasure, the satisfaction, and the good will you will get from using it.

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MASTICATORY FORCES ASSOCIATED WITH THE USE OF VARIOUS TYPES OF ARTIFICIAL TEETH

A PRELIMINARY REPORT

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THERE HAS BEEN considerable lack of agreement regarding the type of artificial posterior teeth best suited to restore and preserve the edentulous mouth. We find that the thinking falls into two major philosophies which center about the virtues of anatomic versus nonanatomic tooth forms. Within the profession, there is one well-defined group of men who feel that the requirements of esthetics, function, physiology, and physics are best met with the anatomic tooth. A second group finds that various modified forms best meet these demands. In general, the opinions of both groups are based upon observations from personal experience rather than upon facts which have been scientifically substantiated.

Evidence that the choice of artificial teeth and the mechanics of their use are controversial appears frequently in the literature. For instance, we read that posterior teeth should be placed over the crest of the ridge; or that their loads should fall to the lingual side of the ridge; or again that we should disregard the ridge and set the teeth where nature placed them originally in the denture space. We are told that cusps provide a stabilizing balance during chewing. This claim is quickly countered by the adage "Enter bolus, exit balance." Flat teeth are said by some to reduce horizontal forces and to load the ridges most favorably in a vertical direction. However, others believe that horizontal components of considerable magnitude are introduced by the flat teeth during the diagonal crushing stroke and by pressures exerted upon balancing ramps when they are employed.

The investigations being reported were prompted by a desire to learn more of the behavior of dentures in function and of their possible effects upon the supporting tissues.

TEST SETUP

Since the specific objective of the studies was to compare the distribution of force to the underlying tissues when various types of posterior teeth were

Read before the Academy of Denture Prosthetics, Miami Beach, Fla., April 14, 1954.

The opinions or assertions contained herein are those of the author and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.

Received for publication June 26, 1954.

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used on full dentures, it was necessary to adopt means by which all factors related to the dentures could be kept constant except for the desired changes in the occlusion. Obviously duplicate dentures would not satisfy this requirement, so cast metal bases were used with four interchangeable dentitions. This insured identical jaw relations, fit, and comfort.

Three types of porcelain teeth were used for comparison. They were zero-degree Geometric, 20-degree Diatoric, and 30-degree Pilkington-Turner, all manufactured by the Dentists' Supply Company. These were selected because they were representative of teeth in common use, and were readily adaptable to all of the situations to be tested. The fourth type of teeth used was that made of plastic with metal cutting inserts designed by Hardy and manufactured by the Austenal Laboratories, Inc.

Measurement of the chewing forces was accomplished through the use of electronic equipment with SR-4 strain gages strategically placed upon the metal bases of the test dentures. Details regarding the procedures to obtain these measurements will be discussed later.

A highly cooperative patient who had been edentulous for about five years was selected for the studies. His ridges were well formed and with sufficient inter-ridge space to permit fabrication and placement of the sectional dentures.

Impressions were made and stone casts were poured in a routine manner. Then two duplicate sets of casts were made, and the three sets of casts were mounted on the same Hanau articulator, using identical face-bow and maxillomandibular relations. Conventional acrylic dentures with 20-degree posterior teeth were constructed first to check the accuracy of the maxillomandibular registrations, including vertical dimension, and to prove the general acceptability of the dentures to the patient.

After the registrations were found to be satisfactory, a second, or interim, set of dentures with metal bases was fabricated for the patient to wear until testing of the sectional dentures was completed. It was felt that the cast bases which were to be used subsequently for the sectional dentures would fit the tissues more accurately for testing if the patient also wore conventional dentures with cast bases immediately prior to the tests rather than dentures with acrylic bases. Zero-degree Geometric teeth were selected for use on the interim dentures since they were the most foreign to the patient of any of the standard teeth to be tested. This provided the patient an opportunity for learning, which was felt to be necessary with the flat teeth.

PRELIMINARY EXPERIMENTS

Before the test bases were made, experiments were conducted with gold and chrome alloy castings to determine the most satisfactory manner of measuring pressures in localized areas. The best results were obtained by slitting a chrome alloy casting to provide a flap-type area 7 mm. in diameter with an attachment of 4 mm. at one point on the circumference. Upon the island of metal so provided, an SR-4 strain gage was cemented and connected to a standard Wheatstone bridge circuit with suitable amplifying and recording equipment. Pres-

sures exerted upon the island caused deflections in the recordings. By loading the area with known weights, it was possible to prepare a chart for the measurement of subsequent unknown loads. An important observation in the study for testing methods was that the greater the rigidity of the casting around the test area, the more reliable were the results. Flexibility throughout a casting was found to permit artifact responses from the gages due to strains being carried into the test area from pressures exerted outside.

TEST BASES

Because it was desired to compare the pressures imposed by the denture against the tissues when the different types of teeth were used, it was decided to place strain gages on cast chrome alloy bases subjacent to the mesial aspect of each first molar to permit measurement of the forces. The testing islands were placed in this location at the crest of the ridge, on the buccal surface and on the palatal or lingual surface of each quadrant. This provided a total of twelve measuring areas throughout the bases.

The circular slits which formed the islands were created by inserting incomplete bands of 0.004-inch stainless steel into the wax patterns and removing them after the casting were made (Figs. 1 and 2). Attachment of the islands to the castings was maintained by continuity of the metal through the gap in each band. All islands were 7 mm. in diameter, with 4 mm. attachments except those at the crest of the lower ridge. Because of the narrowness of the ridge in this area, the diameter of the test islands was reduced to 6 mm. and the attachments were reduced to 3 mm. Rigidity of the bases, to eliminate artifact responses from the strain gages, was insured by the use of full metal borders and by the incorporation of a rib effect around each group of three islands.

After completion of the metal bases, eight impressions were made of the denture side of each base to provide four sets of refractory investment casts, and four sets of stone casts. The refractory investment casts were used in the fabrication of small castings, as suggested by Trapozzano,[1] to accurately orient and attach each of the sections to its base. The duplicate stone casts were used later for the final waxing and processing of the various denture sections.

The test bases were placed on the casts of the mouth which had been mounted previously to the same registrations as were used for the original and interim dentures. In turn, the four types of teeth were articulated on the bases. Care was taken to place each set of teeth in the same relationship to the ridges and to maintain as identical an orientation of the occlusal plane as possible. Teeth of each type were selected in a mold which provided nearly the same size food table throughout. In the case of the Pilkington-Turner teeth, it was necessary to substitute mold 30 upper molars for the mold 33, which were used in the remainder of the setup, to stay within the table size of the other dentitions. It was found that the cutting blades of Hardy's teeth were considerably shorter than the occlusal length of the other posterior teeth, but the balancing ramps increased what might be called the occlusal system to the same length as the other occlusal tables.

TYPES OF OCCLUSION TESTED

Typical situations of occlusion were created to permit the testing of the different types of teeth under conditions commonly encountered in practical cases. This was done by varying the steepness of the incisal incline guide to suit the type of tooth being used while maintaining the same condylar guidances for all situations. With the zero-degree Geometric teeth, the guide platform was set at zero degrees in both anteroposterior and lateral directions. All of the

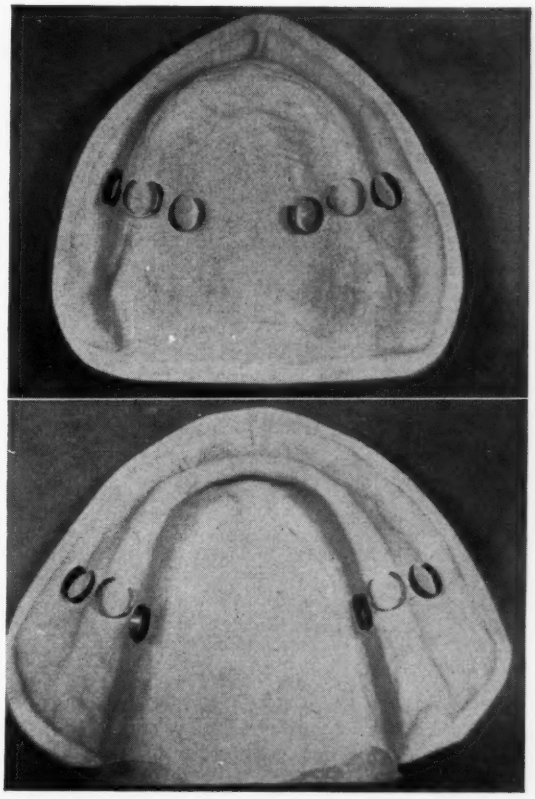
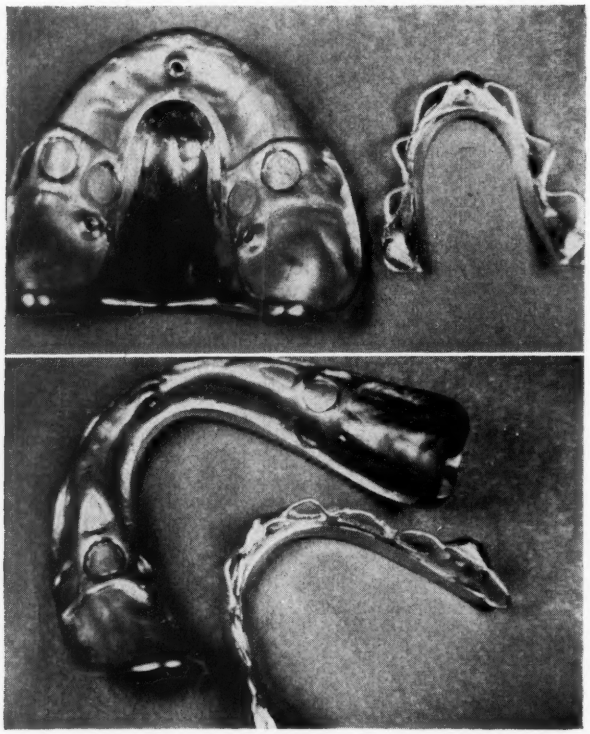


Fig. 1.—Refractory investment casts with incomplete bands of stainless steel to form circular slits in the chrome alloy bases.

teeth were then set on a flat plane with the exception of the anteriors and the second molars which were made to balance in protrusion and in the nonworking lateral excursions. In using Hardy's teeth, the same guidances were maintained, and all teeth were again set on a flat plane except the anteriors which were balanced with ramps behind the molars in protrusive and nonworking lateral excursions. When 20-degree Trubyte teeth were used, the incisal incline guide was still kept flat, permitting the balancing of all teeth in protrusive and lateral excursions with minimum cusp inclines. This was done in line with the theory and practice of reducing the inclines to reduce the horizontal components of forces imparted to dentures during chewing.

Only with the 30-degree Pilkington-Turner teeth was the incisal incline guide elevated from a flat plane. If the flat plane had been maintained, many of the inclines of these teeth would have been reduced to the same inclinations as existed with the 20-degree teeth during equilibration, and a nearly identical testing situation would have prevailed. Therefore, to create as great a variation as reasonable within the range of mandibular movements, the anteroposterior angle of the incisal incline guide was set at 19 degrees. This inclination was chosen as it

A.



B.

Fig. 2.—*A* and *B*, Completed bases with metal band inserts removed. Full cast borders and reinforced areas around each testing island provide rigidity to prevent artifact responses from the strain gages. The small attachment castings are shown.

was the same as the flatter of the articulator's condyle guide settings. It was felt that it was the greatest angle at which anteroposterior jaw movements would be in harmony with cusp inclines. As a means of maintaining a greater inclination of the cusps in lateral excursions, both wings of the incisal guide table were set arbitrarily at 10 degrees. This provided a further variation from the articulation of the 20-degree teeth.

After the teeth were set up, all of the upper denture sections were processed prior to the lower denture sections, to permit adjustment of the lower teeth in the wax to compensate for possible shifting of the upper teeth during curing.

In this way it was possible to minimize the amount of grinding necessary for occlusal equilibration and to retain the original anatomy to the fullest extent.

It was felt that the patient must be afforded an opportunity to become familiar with each dentition (Fig. 3) before the chewing tests were conducted. Therefore, he was allowed to wear the various sections for whatever time he felt necessary for complete orientation. A smooth transition from the use of one type of tooth to another was provided by having him wear a familiar type immediately before a somewhat similar unfamiliar one. Thus, the 20-degree tooth sections were worn prior to the 30-degree, and the zero-degree were worn prior to Hardy's teeth. No difficulty was experienced with any of the sections, but the patient requested to use the 30-degree and Hardy teeth for 48 hours, whereas he found 24 hours sufficient for the other sections. Care was exercised to avoid influencing the patient's reactions to the use of the various teeth and to keep him entirely unbiased regarding their characteristics and performance.

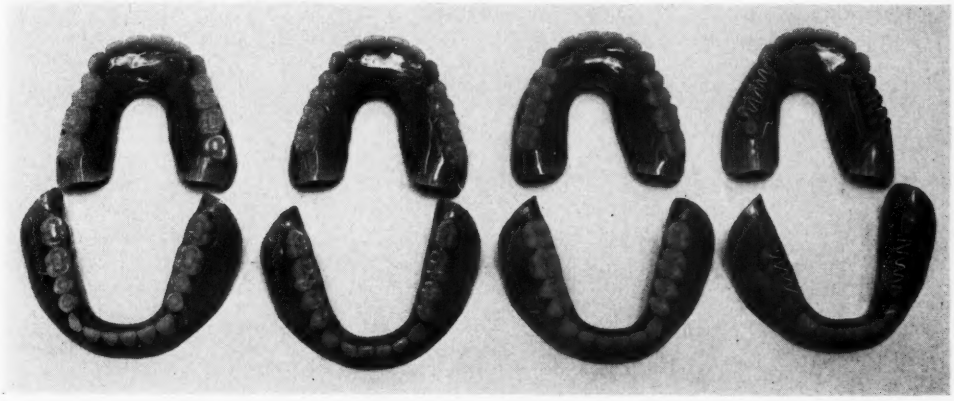


Fig. 3.—Various dentitions used in the studies. From left to right the posterior teeth are: Zero-degree Geometric, 20-degree Trubyte, 30-degree Pilkington-Turner, and Hardy teeth with metal cutting blades.

After he was satisfied that he could masticate well with all four dentitions, the nonsectional cast base interim dentures were returned to him and the test dentures were retained for placement of the strain gages.

A SR-4 gage was cemented to each of the twelve test islands and connected to the amplifying and recording equipment (Figs. 4 and 5). Twelve additional gages were required to permit balancing of the circuits at various temperatures. Since there was not sufficient space to place these gages on the denture bases, it was decided to cement them to a plate of chrome alloy which could be kept at any desired temperature outside of the mouth. The plate and gages were insulated and waterproofed so they could be placed in a body temperature bath while the chewing tests were being made. The constant temperature was provided by placing a variable resistance in series with the power supply of a standard impression compound heater and by mechanically agitating the water (Fig. 6).

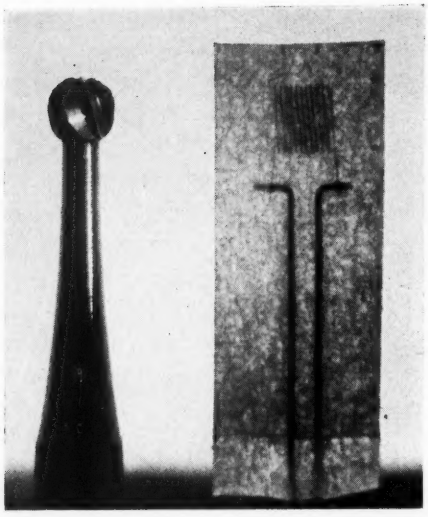


Fig. 4.—A SR-4 strain gage is compared with a number six round bur. Transillumination reveals the high resistance grid which varies the passage of carrier current when deformed.

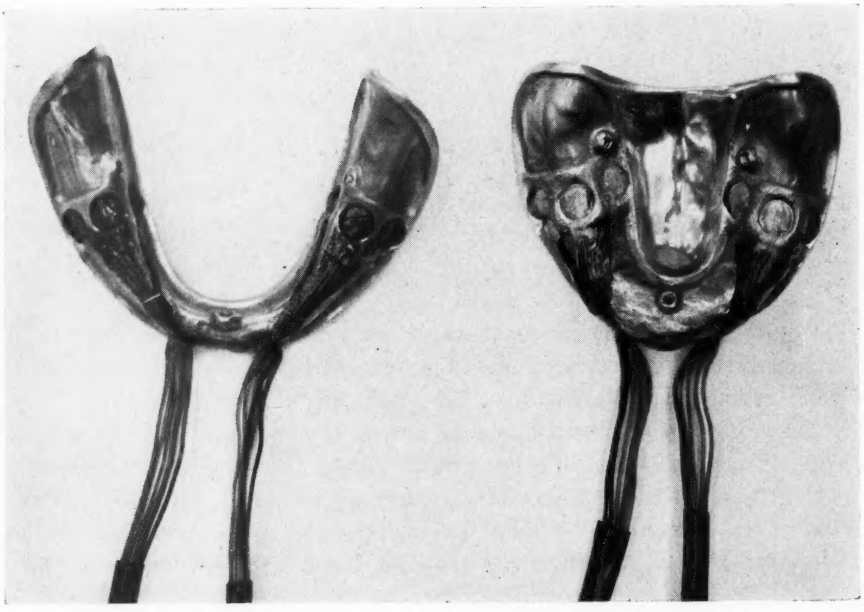


Fig. 5.—Strain gages and lead wires cemented to the cast metal bases.

TEST PROCEDURES

The electronic carrier system, amplifiers, and recorder were placed in operation and preliminary chewing tests were conducted (Fig. 7). Following this, attempts were made to calibrate the strain gages by applying known dead weight and spring tension loads to the dentures above each testing island perpendicular to the supporting tissues. It was soon found impossible to calibrate the gages in this manner because of at least two apparent reactions of supporting tissues to pressures transmitted to them through a denture. The first is that the tissues appear to move in unison with the denture, no matter how well fitting, in the same manner as an open door moves with any force that is applied to it. The

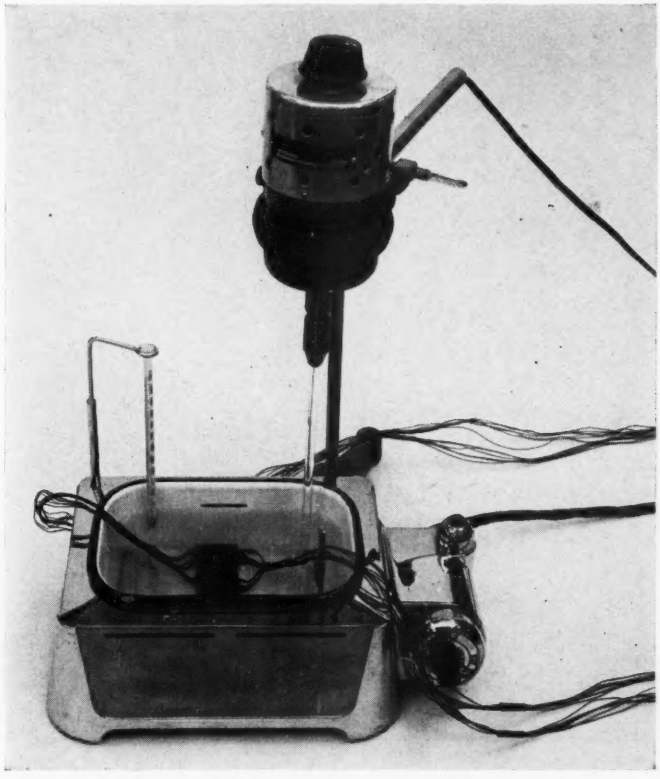


Fig. 6.—Equipment used to maintain constant temperatures of compensating gages during testing.

movement continues until the least resilient areas resist the applied force, at which time there may not be sufficient backward pressure at the more resilient areas to permit measurement. A second factor also makes calibration of the gages impossible regardless of the force applied in certain areas. This was most noticeable at the slopes of the palate in the molar region where pressures up to 25 pounds were applied at right angles to the tissues without creating appreciable responses in the gages located at those points. It appeared that, unless ad-

ditional vertical pressures were exerted to maintain the denture stable in its original position, the tissues were not confined in their original form and tended to flow like fluid toward points of least resistance. This theory seemed to be borne out during the chewing tests when the forces of mastication kept the dentures well adapted to the tissues, confining them and causing adequate responses from the gages.

Since it was not possible to calibrate the gages to indicate the loading of the tissues by the denture as a whole when known forces were applied, it was necessary to calibrate for pressures exerted by the individual test islands. The cali-

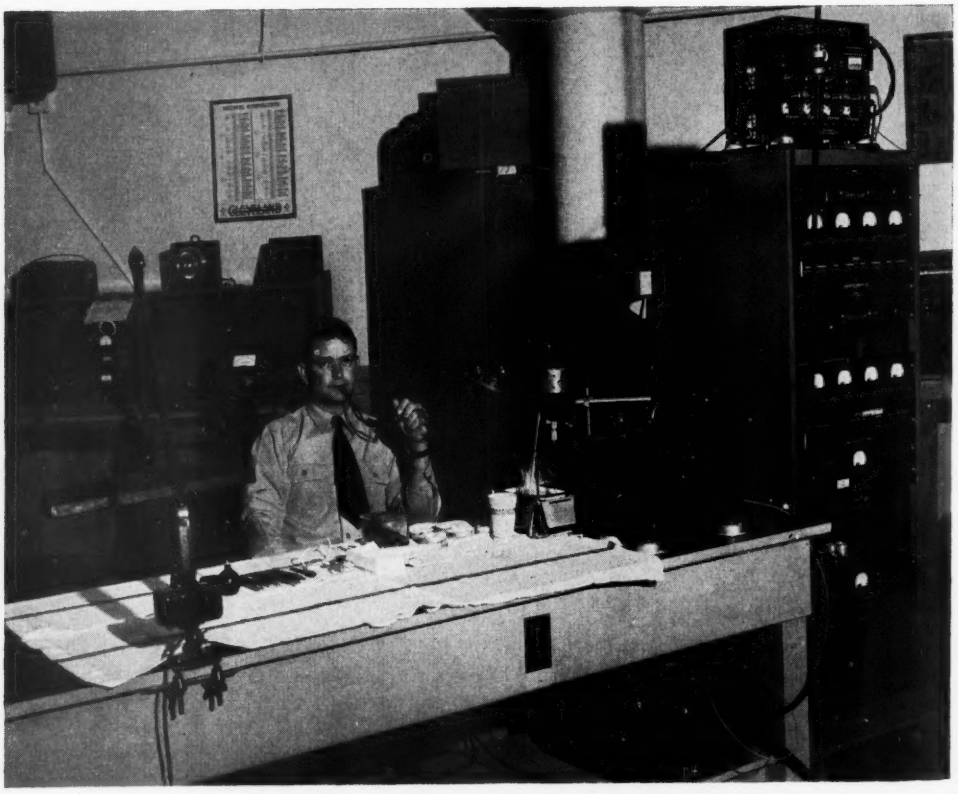


Fig. 7.—The patient with equipment used in the studies.

bration was accomplished by first placing a piece of rubber dam over each island to seal the surrounding slit, and then applying air pressure through a brass tube which was well adapted to the contours of the metal base just outside the slit (Fig. 8). By this means it was possible to prepare a chart to indicate the pressures which were required to cause various deflections on the oscillograph recording (Figs. 9 and 10). The chart was then used to convert millimeters of deflection to pounds of pressure per square inch exerted by each island during chewing with each type of tooth.

Before the tests were made, the patient was questioned as to his side of preference for chewing because this information was deemed important for subsequent analysis of the recordings. He stated without hesitation that he always chewed on the left side. As the studies progressed, however, it was revealed that he never chewed unilaterally but always spread the food on both sides

Fig. 8.—Air pressure applied to a test island for calibration.

to aid in stabilizing the dentures. This was done in spite of unusually satisfactory retention, stability, and balance of the dentures in all functional excursions. The chewing habit was actually one of bilateral chewing with a preference for the left side rather than one of unilateral chewing on the left. This fact seemed to indicate the advisability of permitting the patient to chew at random during the tests rather than to force him to chew unilaterally.

TEST FOODS

It was originally intended to use only carrots and peanuts in the studies since carrots have been accepted generally as characteristic of hard foods of the diet while peanuts have characterized the softer foods. Preliminary recordings showed, however, that more pressure was involved in the chewing of peanuts than carrots, so it was felt that another more resistant food should be included in the tests. In the belief that roast beef would serve as such a food, it was added to each chewing series; but the tests which followed failed to bear out the assumption that it required greater pressure for mastication than did the other foods. The meat was tender, well-cooked, and cut into pieces approximately three-eights by three-quarters of an inch. Three of these pieces, which were not standardized by weight, were chewed for each recording. The salted jumbo peanuts and three-eights-inch cubes of carrots were measured, however, into portions which weighed 3 Gm.

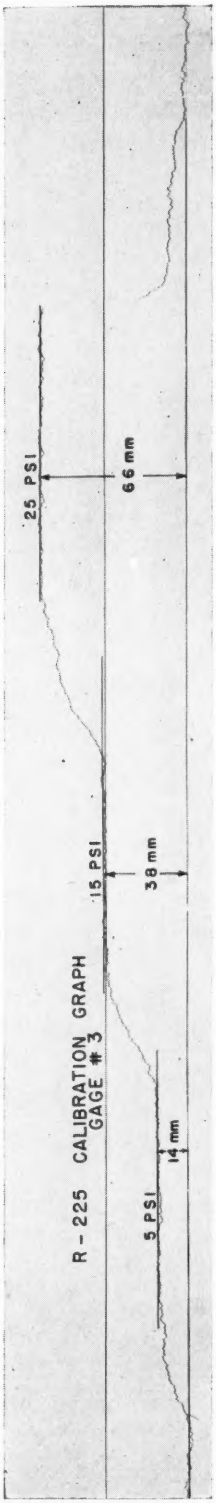


Fig. 9.—Recording for calibration of gage in right palatal area.

During the preliminary tests, it was decided to temporarily discontinue testing of the lower denture because of the unexpected amount of time required to make twelve satisfactory recordings simultaneously and because of the gigantic task of making over 9,000 determinations necessary for each day's testing of one denture. Therefore, a series of tests were conducted with the upper denture

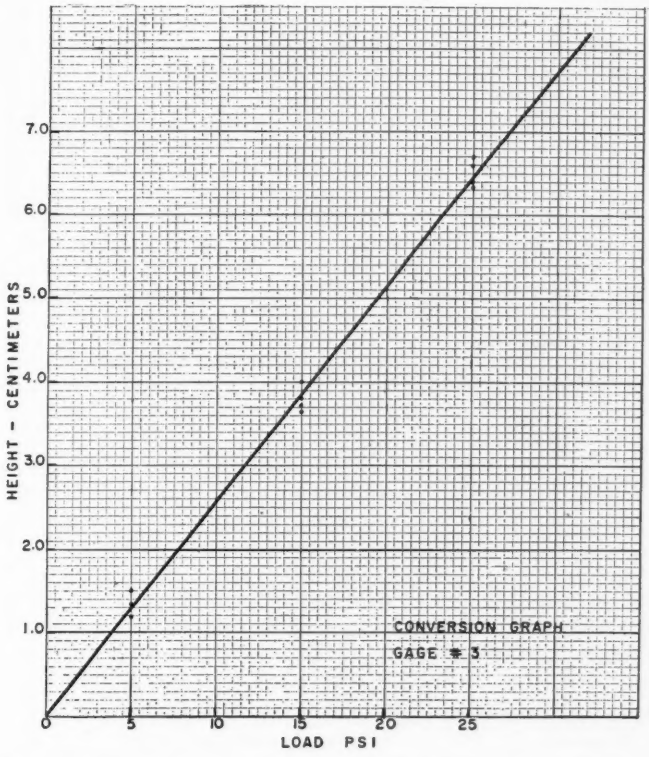


Fig. 10.—Sample chart used to convert millimeters of deflection in the recordings to pounds of pressure per square inch.

on four consecutive days using the four sets of teeth in a constant sequence but starting with a different set each day. Three records of twenty random chewing strokes were made each day during the chewing of each type of food with each dentition (Fig. 11). These records were scored for the height of deflection at each chewing stroke, and the pressure per stroke was charted. All pressures for each situation tested during the 4-day period were then pooled and averages taken. The results permit a comparison of force distribution between 30-degree, 20-degree, zero-degree, and Hardy teeth since they show the average pressures in six areas of the upper denture obtained from twelve records of twenty chewing strokes for each of the four dentitions with each test food.

OBSERVATIONS RELATIVE TO MASTICATORY PRESSURES

In 20 out of 24 instances, more pressure was exerted with peanuts than with carrots (Fig. 12).

In 14 out of 24 instances, equal or greater pressure was exerted with peanuts than with roast beef.

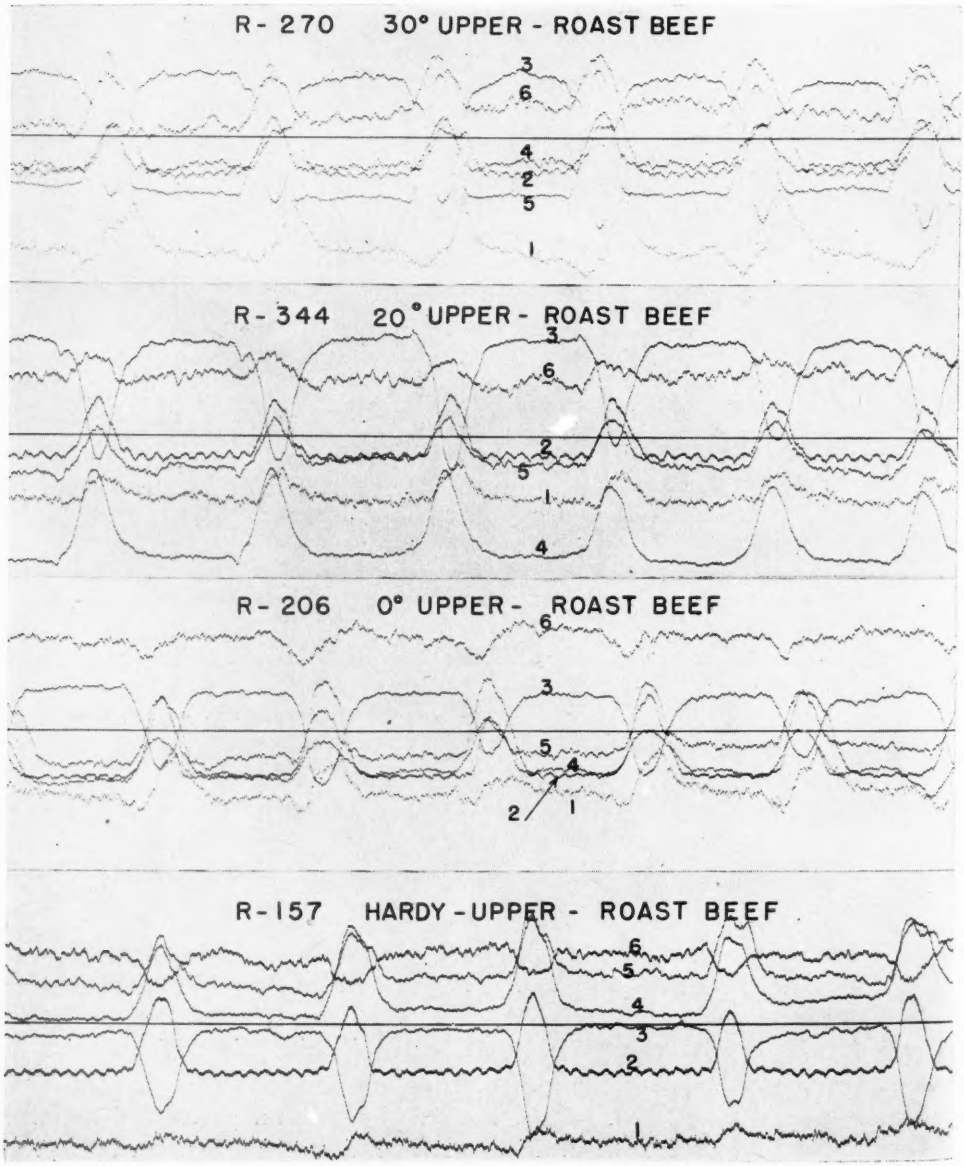


Fig. 11.—Tracings from six areas of the upper denture during the chewing of roast beef with each type of teeth.

In 19 out of 24 instances, more pressure was exerted with roast beef than with carrots.

If the average of the pressures used in chewing the three types of food is taken for each type of tooth in each area, a general comparison between the pressures exerted with the various teeth may be observed. In making the comparisons, it is probably well to consider first the findings pertaining to the 30-degree, 20-degree, and zero-degree teeth as a group, and then relate the Hardy teeth to the others.

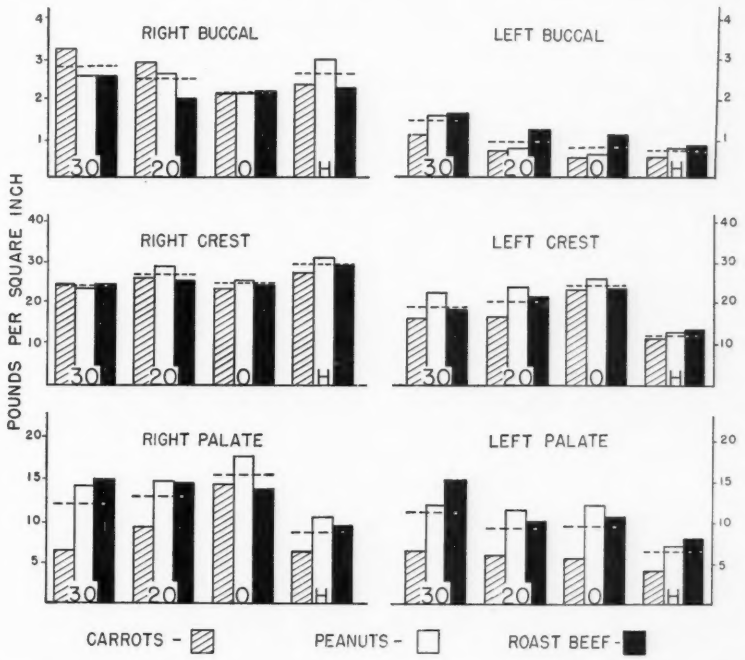


Fig. 12.—Graphs of the pressure exerted against the tissues by the upper denture in six areas. The dotted lines indicate the average of the pressures used in the chewing of the three test foods.

Any pressure shown in one area may be related to other pressures in the same area because all factors were constant except for the types of teeth used. Pressures in different areas may not be related directly, however, since the test islands were not necessarily placed upon areas of similar density.

There were instances in which the peaks recorded during chewing were reverse from those found when direct pressure was applied to a testing island. This occurrence was attributed to a pull on the island toward the tissues, probably as a result of negative pressure and adhesion between the base and the tissues during certain movements of the denture. No attempt was made to evaluate the magnitude of these negative pressures, but when they occurred they were scored as zero to indicate the absence of positive pressure. Therefore, all pressures shown in Fig. 11 are the averages of positive pressures recorded for the situations indicated. The average in each area of a recording was obtained by dividing the total of the positive pressures by 20, the number of chewing strokes.

COMPARISON OF PRESSURE DISTRIBUTION WITH 30-DEGREE, 20-DEGREE, AND ZERO-DEGREE TEETH

30-DEGREE TEETH

Showed less pressure than any of the other teeth at the crest of the ridge on both sides of the arch.
Showed more pressure in three of the four "lateral" areas than did the other teeth.

20-DEGREE TEETH

Registered greater pressure than the 30-degree or zero-degree on the ridge crest of one side and pressure between the two on the other side.
Registered pressures between those of the 30-degree and zero-degree teeth in three "lateral" areas and less than either in the fourth area.

ZERO-DEGREE TEETH

Showed the greatest pressure of any of the teeth on the ridge crest of one side and the least amount on the other.
Showed the least pressure in two "lateral" areas, nearly identical to the 20-degree teeth in the third area, and the greatest pressure of any of the teeth in the fourth area.

COMPARISON OF THE HARDY TEETH TO THE 30-DEGREE, 20-DEGREE AND ZERO-DEGREE TEETH

HARDY TEETH

Registered the least pressure of any of the teeth at the ridge crest on one side and the greatest of any on the other side.
Registered less pressure than any of the other teeth in three of the four "lateral" areas.

CHEWING PERFORMANCE

In addition to the analysis of force distribution, the relative performance of the various teeth in masticating food was considered to be of special interest. This information was obtained by conducting a 4-day series of performance tests in the manner suggested by Yurkstas and Manly.[2] Five portions of peanuts, each weighing 3 Gm., were chewed for twenty strokes and the combined chewed particles were washed on a 10-mesh screen. The necessary volumetric measurements were made and the performance was computed by dividing the volume of particles passing the 10-mesh screen by the total volume of food recovered from the mouth. The data obtained from the 4-day test of each dentition were pooled and averaged to determine the final performance for each type of teeth.

Performance in the mastication of peanuts was as follows: 30-degree teeth—81.40 per cent, 20-degree teeth—75.61 per cent, zero-degree teeth—74.66 per cent, Hardy teeth—50.46 per cent.

OBSERVATIONS OF THE PATIENT REGARDING THE VARIOUS TYPES OF TEETH

The 30-degree teeth were excellent cutters but restricted free movements of the jaw and tended slightly toward packing of the food.

The 20-degree teeth were satisfactory in all respects and were preferred to the other teeth.

The zero-degree teeth were first observed as being "mashers" and were accepted with skepticism. They were later thought to be very satisfactory, however, although not efficient for cutting.

Hardy's teeth were excellent cutters but poor crushers. Food lacked full flavor and remained in well-defined particles even after prolonged chewing.

GENERAL OBSERVATIONS

Conclusions or deductions from the report of a single case should be made with caution. Sufficient cases must be reported to eliminate the element of chance results or peculiarities of individual patients before definite conclusions can be made.

Factors related to tissue movement under artificial dentures are thought to be of special interest. It may be that ill-fitting dentures permit flow of the poorly confined resilient tissues which results in concentration of force in the less resilient areas. In contrast, broad distribution of force may occur through the tissues, as through a fluid, when the tissues are confined in a well-fitting denture. These factors may strongly influence both the stability of the dentures and the health of the supporting structures.

The responses of the strain gages which appeared to result from negative pressures may be indicative of various degrees of instability of the dentures incident to reduction in intimate contact with the tissues.

In spite of the patient's belief that he chewed unilaterally on the left side, it was revealed that he actually chewed bilaterally to obtain maximum denture stability. A similar condition may occur with sufficient frequency in other patients to merit consideration in studies of mastication.

Foods which have been used in masticatory tests to determine force, performance, and efficiency are considered to be inadequate for scientific investigations because they do not lend themselves to standardization in any manner. It is felt that it may be necessary to develop facsimile or simulated foods which will permit repeatability of results and comparison of the findings of various workers. This is certainly not possible with natural foods.

It is imperative that further investigations be undertaken to determine more of the mechanical and biologic influences of artificial dentures upon the supporting structures if we are to serve our patients properly in the restoration and preservation of their edentulous mouths.

I wish to acknowledge indebtedness to J. C. Thompson, B. S., F. D. Carpenter, B. S., J. L. Eitel, E. E., and others of the U. S. Naval Electronics Laboratory, San Diego, California, for their counsel and technical assistance in these studies; and to enlisted personnel of the U. S. Naval Training Center, San Diego, California, for compiling data and assisting in other phases of the work.

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A METHOD OF MEASURING FORCES OF DENTURE BASES AGAINST SUPPORTING TISSUES

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THE MANDIBULAR and maxillary soft tissue coverings and their underlying tissues are the foundational structures upon which the stresses of mastication with artificial dentures are dissipated. The purpose of this study was to outline a procedure for measuring these stresses in the hope that this would furnish a means for gathering data relative to many of our denture problems. A preliminary study using this procedure was followed in the measurement of lateral stress to the supporting tissues under dentures. A comparative study was made using dentures constructed with zero degree teeth and duplicate dentures with anatomic teeth which had been adapted and modified to the patient's requirements.

REVIEW OF LITERATURE

In reviewing the literature, it is found that many attempts have been made to measure and evaluate masticatory forces. Black,[1] while believing that the masticatory force exceeded the minimum force required to pulverize food, crushed foods between two upper and two lower molars with a lever type instrument and found some foods required a crushing range between 5 to 90 pounds.

Head[2] and Schroeder[3] found that smaller forces were required if a shearing movement was used rather than a straight compression as Black had used in his hinge type lever instrument.

Brawley and Sedwick,[4, 5] in reviewing the literature prior to 1938, found thirty-one references to different instruments for use in measuring biting force.

Howell and Manly[6] list some seventeen other instruments or procedures that were used from 1938 to 1948. These included one by Boos,[7] who mounted his Bimeter on upper and lower artificial dentures and found that patients are capable of exerting a straight vertical pressure of mandible to maxilla of from 13 to 100 pounds.

Klatsky,[8] by having patients bite upon a gnathodynamometer with a force which they thought would equal that used during mastication, found that force to be about one-fourth of the maximal force which they were able to exert on the instrument.

Various studies have been made to determine the efficiency of different tooth forms or occlusal designs, such as the work of Schultz,[9] Trapozzano,[10] Payne,[11]

Read before the Academy of Denture Prosthetics, Miami Beach, Fla, April 14, 1954.
Received for publication July 7, 1954.
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and others.[12, 13] All showed, in general, that so-called "anatomic teeth" were more efficient but made no comparisons of vertical or lateral stresses upon the supporting tissue. Payne also noted that the masticatory stroke varied with the type of cusps that had been used. There was more lateral slide with the zero degree cusps in order for the patient to increase cuspal efficiency.

In 1948, Howell and Manly[6] were the first to adopt the electronic strain gauge for measuring oral forces and measured maximum biting force with it. In 1950, Manly, Yurkstas, and Reswick[14] adapted their type of strain gauge to the measurement of tooth mobility. In 1951, Brudevold[15] adapted the strain gauge to the measurement of chewing forces on the two left maxillary bicuspids and first molar of a denture wearer using zero degree cusp posterior teeth. The measurements were taken during normal chewing of nineteen types of food. He found that "greater total force was produced by increasing the number of chews, rather than by increasing the force of a single chew." He also states that some of his comparisons "suggest that a shearing movement was used" because, "generally the chewing was done with a lateral stroke of the mandible since available data from mechanical experiments indicate that the chewing forces were too small to bring about crusing of certain food with a straight hinge axis."

It can be seen that much has been done to measure the total amount of force upon a denture, pressure upon individual teeth, and efficiency of the teeth; and some study has been made concerning the factors which influence the amount of this force, but nothing has been reported concerning attempts to measure the forces at the place where they must ultimately be resisted and dissipated or to determine in what direction they must be resisted by the contacting tissues.

PURPOSE OF THIS STUDY

This study was undertaken to adapt available equipment to the problem of measuring pressures exerted by denture bases. Very little consideration has been given to what induced or varied the amount of that stress. After the method for measuring such forces has been satisfactorily adapted, then the problem concerning the stress-producing factors can more easily be studied. Because of the great complexity of the problem, nothing in this article is meant to construe other than that this is only a preliminary study of adapting equipment for the above-mentioned purpose followed by some very preliminary trial runs of equipment testing. All conclusions drawn at this preliminary stage must of necessity be subject to further study.

DETAILS OF APPARATUS USED

Alderisio[16] described an electronic technique permitting multiple registrations of oral myodynamics which is somewhat similar to that used in this study; however, there is enough difference to justify a brief description of the materials used.

Basically, the measuring device is a Wheatstone bridge (Fig. 1). The resistors used as gauges *A* and *B* are a suitable size of the Baldwin Sr-4 strain gauge (Fig. 2).

The quantity actually measured in such a gauge is the change in resistance which is responsive to all stresses, whether those stresses be thermally induced or due to applied load or both.

The gauges used were mounted on opposite sides of a flat gold spring wire carrier. Thus, as a force is applied at one end of the carrier, a tensile strain would result on one gauge, and a compressive strain would result on the other.

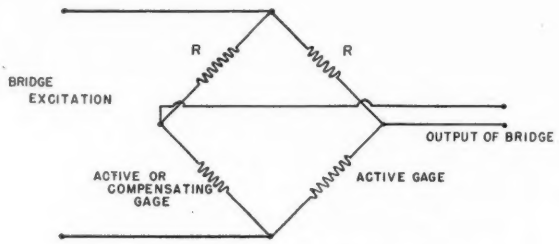


Fig. 1.—Diagram of a Wheatstone bridge.

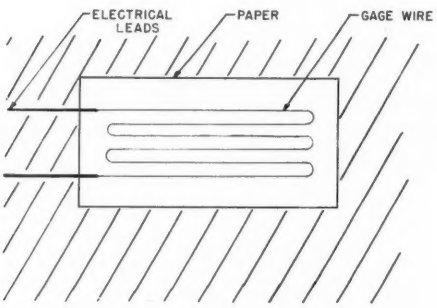


Fig. 2.—Diagram of a strain gauge.

The Wheatstone bridge would be unbalanced in proportion to the sum of the strain acting on the two gauges. The two gauges would be subjected to the same temperature and both would be lengthened approximately the same amount. Thus, by using the gauges in pairs, their sensitivity will be increased, any changes due to temperature or shear variables will be balanced out, and the strain registration will be confined to a vertical displacement.

These gauges are connected to a brush strain analyzer, which provides a source of power for the bridge, as well as an amplifier. Through the use of a brush pen recorder, a written record of the applied forces can be obtained.

As the study was carried on at the College of Medical Evangelists, a Sanborn twin-viso strain gauge analyzer and recorder were used. Thus we were able to record one side at a time, either chewing or nonchewing, or record both sides simultaneously.

PROCEDURE

Duplicate dentures were constructed for a patient using zero degree cusp posterior teeth on one set (Hall's) and anatomic posterior teeth on the other (modified 33° Trubyte). The casts and the maxillomandibular relations were duplicated, and the tooth to ridge relationship was duplicated as far as possible. The teeth on both pairs of dentures were set up in balanced occlusion on a House articulator, after the usual procedure for recording and transferring vertical dimension, centric relation, and protrusive and right and left lateral relations had been carried out. Before any tests were made, the patient was instructed to alternate the wearing of the dentures every three days during a period of six weeks.

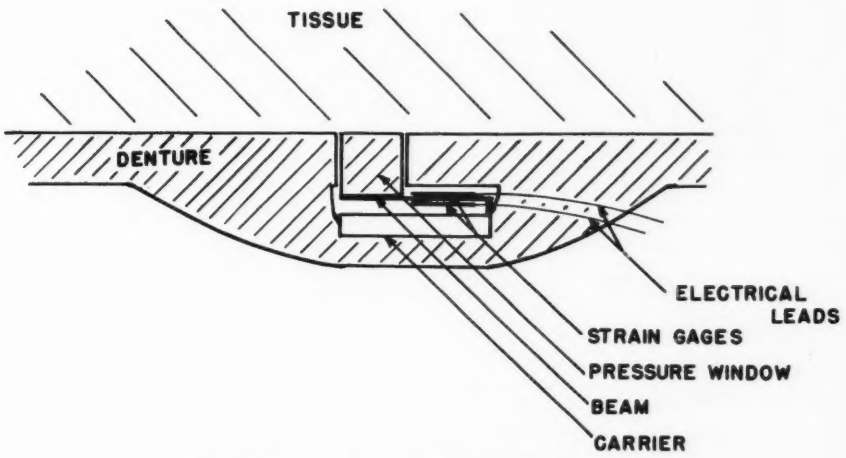


Fig. 3.—Diagram of the sensory unit of a strain gauge.

An area was selected in the buccal flange over each right and left first molar for the location of the strain gauges. In this position they would, as nearly as possible, register only lateral stress with as little vertical interference as possible. A small window, approximately 5 by 5 mm., was cut in the same location on both upper dentures. An acrylic resin plunger was made to fit the tissue surface but with a small amount of freedom on the sides to allow for its free movement in the window space. While this plunger was held in place, it was cemented to the gauges (Fig. 3), and the protective box was anchored to the denture (Fig. 4).

After the denture was inserted and allowed to reach body temperature, the patient was instructed to assume rest position with the teeth separated. The Wheatstone bridge in the brush strain analyzer was balanced, and the brush pen recorder was put in operation (Figs. 5 and 6).

With the gauge mounted in the upper buccal flanges, a record was made of the lateral pressure exerted against the 25 sq. mm. area of the acrylic plungers. The lateral pressure on the chewing side was registered as the patient masticated on the same side as the gauge, and on the nonchewing side as the patient masticated on the opposite side from the gauge.

It should be emphasized that when we refer to lateral pressures, they are the resultants of forces which have several components such as lateral, vertical, and combinations of these. A straight lateral pressure per se is not measured, but practically speaking, this is the force the tissues resist.

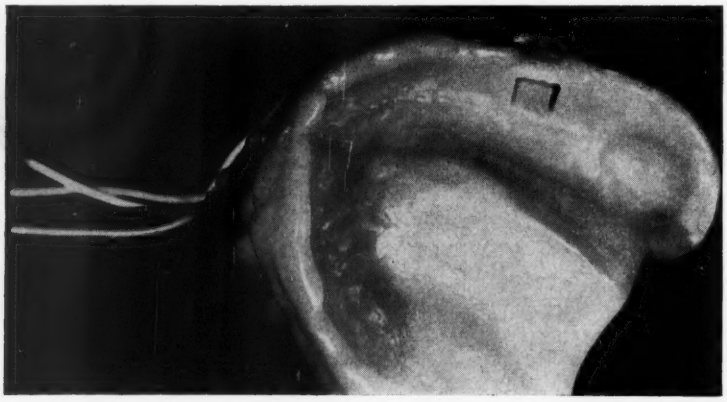


Fig. 4.—A strain gauge in the buccal flange of a denture.

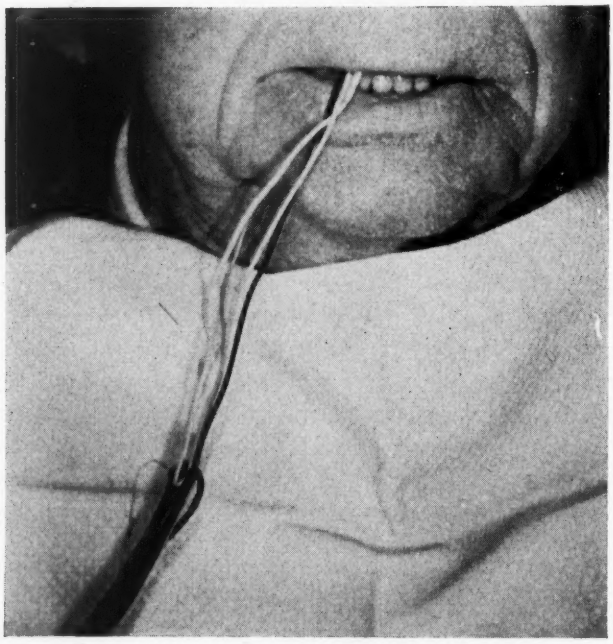
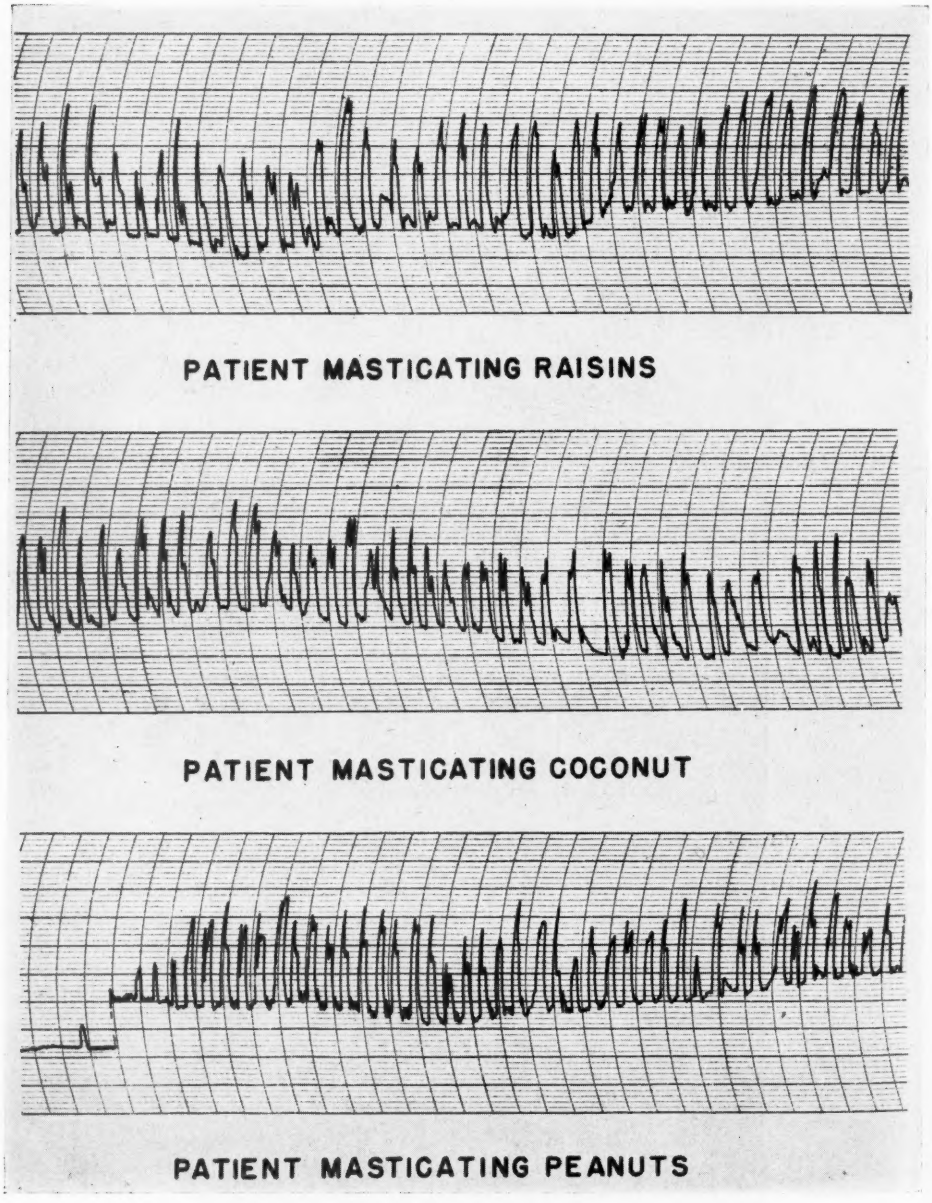


Fig. 5.—Complete dentures with the strain gauges in position in a patient's mouth.

The three foods chosen for this study were raisins, shredded coconut, and peanuts. Comparisons were also recorded without food while the patient exerted his maximum vertical biting force, and while he made movements from protrusive, left lateral, and right lateral to centric occlusion.

Fig. 6.—The strain gauge analyzer and the recording equipment used.

Figs. 7 through 12 demonstrate the resulting recordings with the first patient recording on only one gauge under various conditions. Although at times it was impossible to keep the base line from undergoing a gradual rise or decline (due to an electrical fluctuation), the basic readings are extremely uniform. Each stroke



Figs. 7.-12.—Recordings from a patient with different foods and different dentures but with only one gauge in operation.

Fig. 7.—Lateral pressure on working side of denture (zero mold teeth).
Note: 25 spaces = 32 grams.

is recorded by an upward sweep as pressure is applied and returned to the base line as pressure is released. (The terms used in the charts of "working" and "balancing" side should probably be more accurately described as chewing and nonchewing sides.)

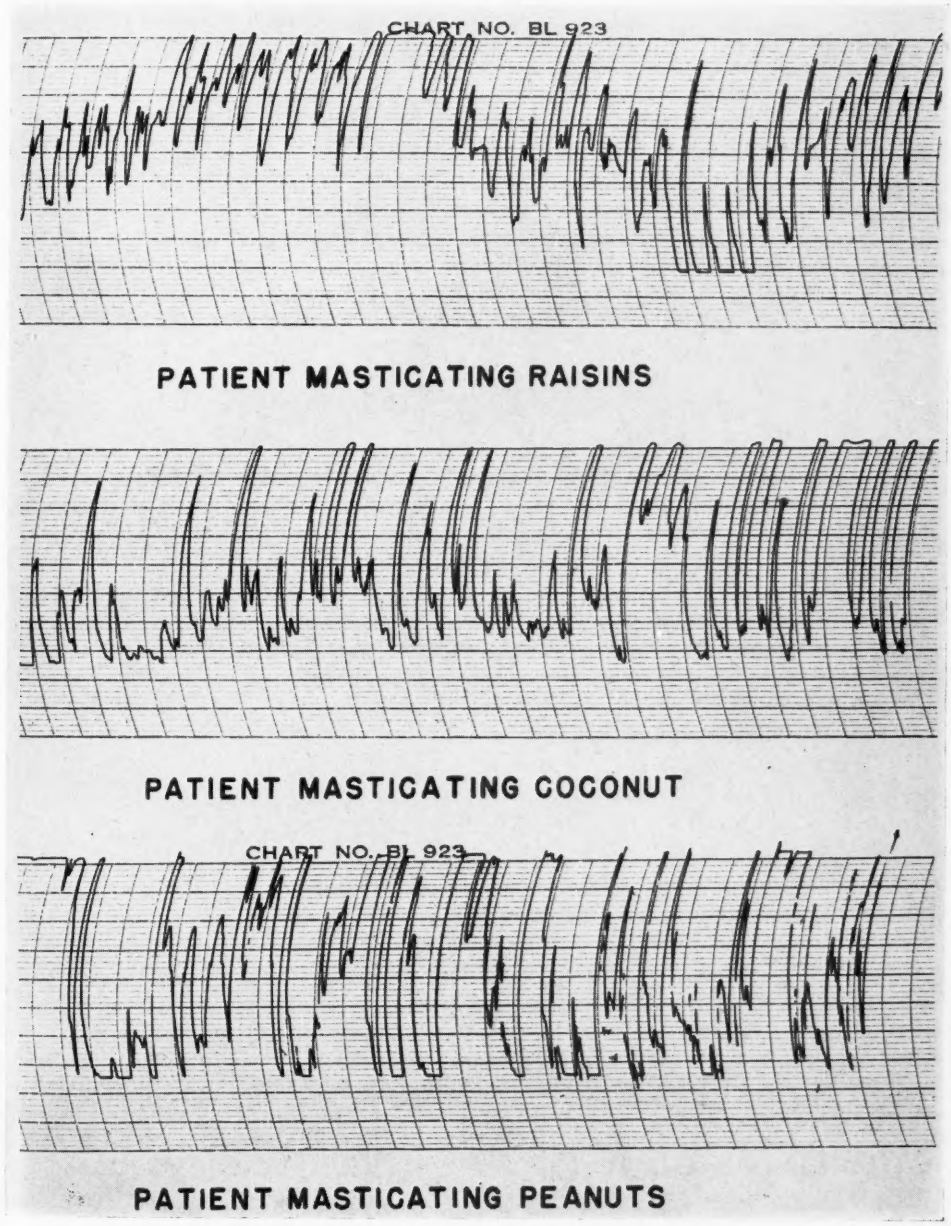


Fig. 8.—Lateral pressure on balancing side of denture (zero mold teeth).
Note: 25 spaces = 81 grams.

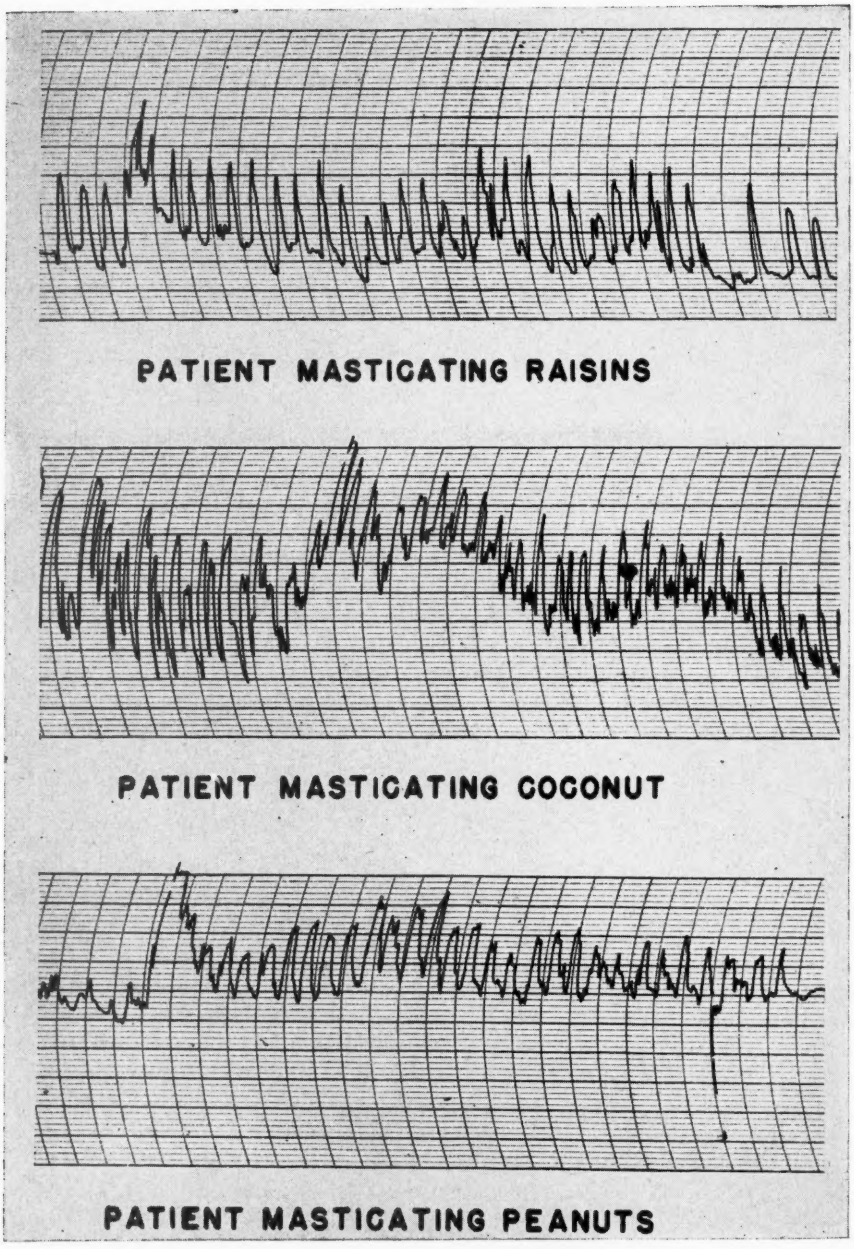


Fig. 9.—Lateral pressure on working side of denture (anatomic mold teeth).
Note: 25 spaces = 92 grams.

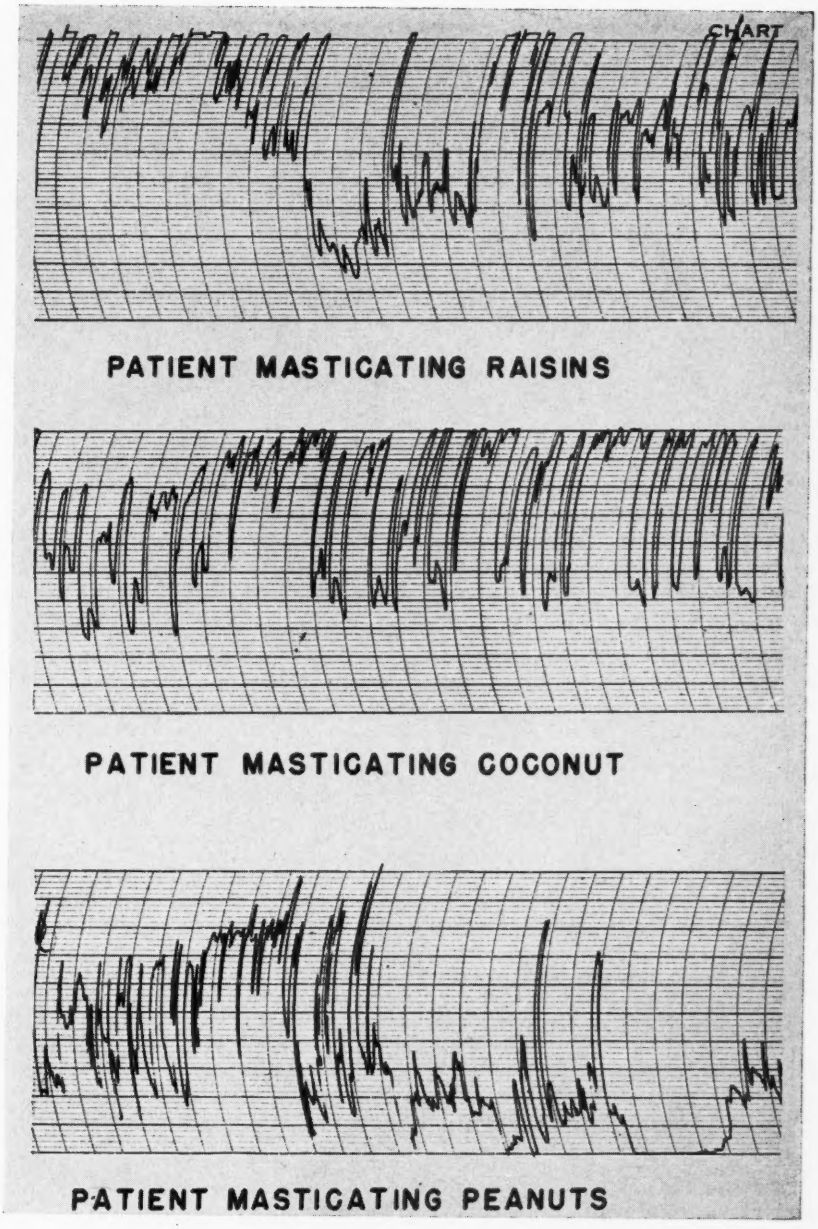


Fig. 10.—Lateral pressure on balancing side of denture (anatomic mold teeth).
Note: 25 spaces = 92 grams.

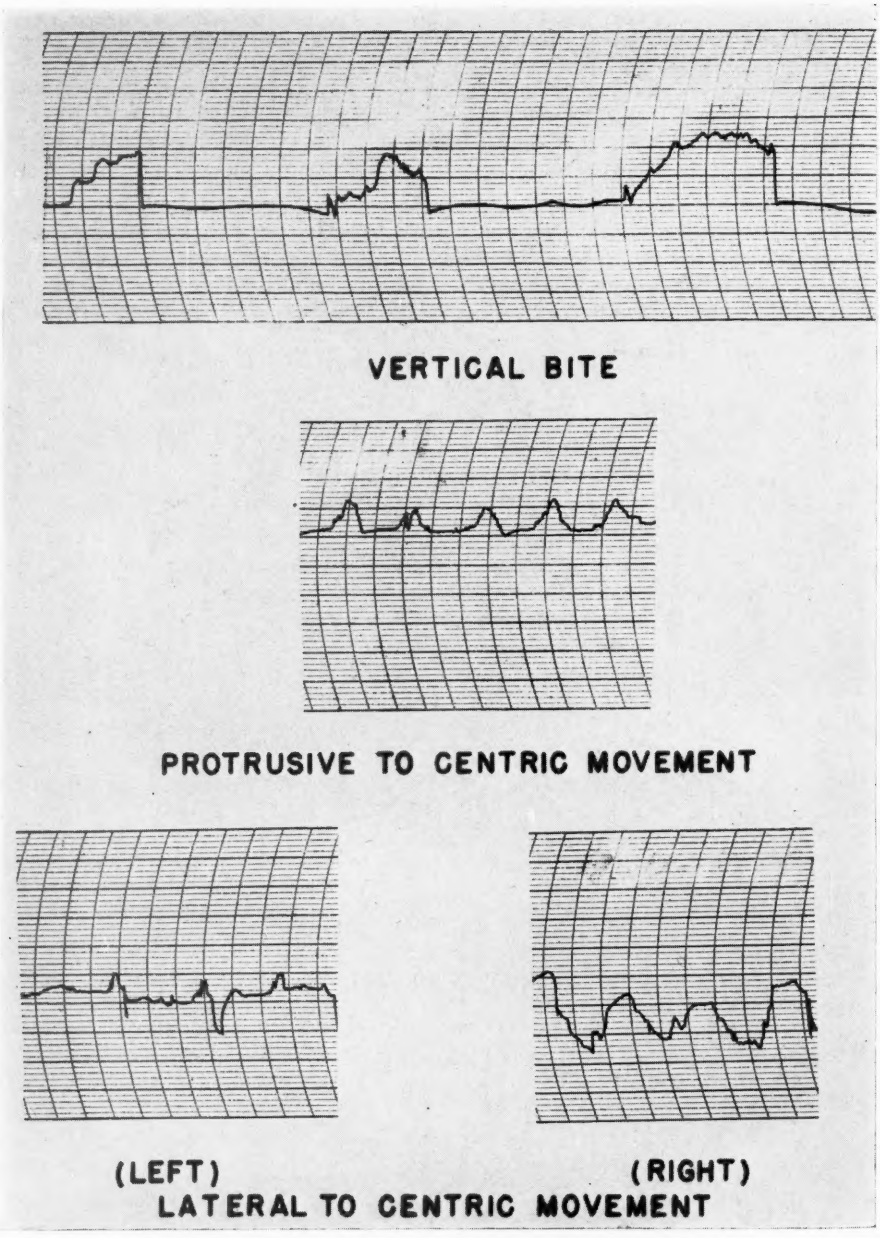


Fig. 11.—Lateral pressure on right side of denture (zero mold teeth).
Note: 25 spaces = 81 grams.

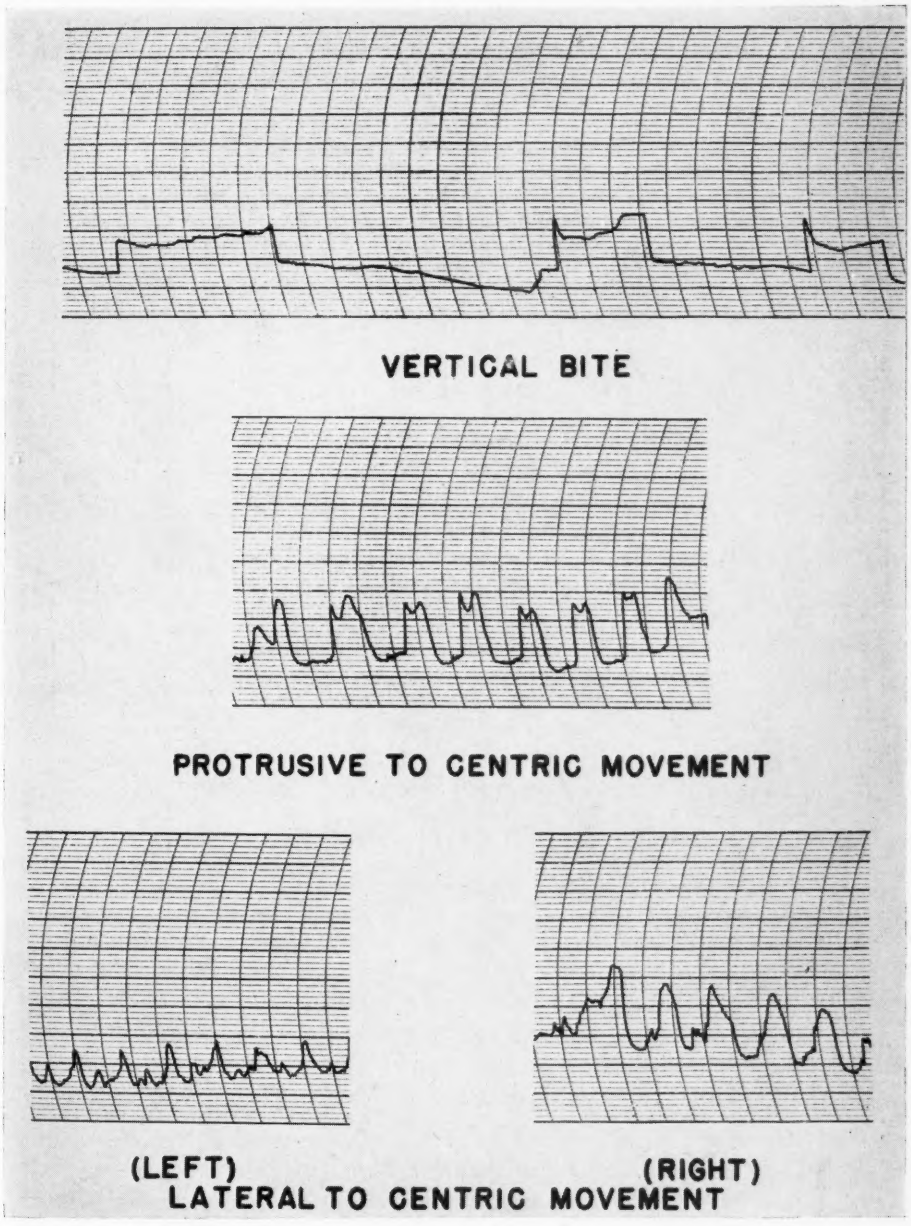


Fig. 12.—Lateral pressure on right side of denture (anatomic mold teeth).
Note: 25 spaces = 92 grams.

Table I shows the data obtained by the calibration of these recordings into grams of pressure.

Figs. 13* through 16 demonstrate the recordings of the second patient when pressures were registered on both the chewing and nonchewing sides simultaneously.

TABLE I. LATERAL STRESS (IN GRAMS)

	MAXIMUM		MINIMUM		AVERAGE	
	ZERO	ANAT.	ZERO	ANAT.	ZERO	ANAT.
Working Side						
Raisins	29.9	74	15.6	29.6	23.4	41.8
Coconut	28.6	92.5	13	29.6	20.8	55.5
Peanuts	27.3	55.5	10.4	22.2	19.5	37
Balancing Side						
Raisins	117	144	39	29.6	71.5	72.5
Coconut	123	118	55	33.3	104	94.4
Peanuts	126.8	144	55	26	110.5	86
Vertical Bite	13	33.3	9	14.8	11	22.2
Protrusive to Centric	19.2	48	15	37	17.6	33
Left Lateral to Centric	28.8	26	22.2	11	24	19
Right Lateral to Centric	39	55	35.2	40.7	38	46

Subsequent Comparisons

	ZERO	ANAT.
Average Working Side (Raisins)	23.4	41.8
Average Balancing Side (Raisins)	71.5	72.5
Average Working Side (Coconut)	20.8	55.5
Average Balancing Side (Coconut)	104	94.4
Average Working Side (Peanuts)	19.5	37
Average Balancing Side (Peanuts)	110.5	86

Table II shows the data obtained by the calibration of these recordings.

OBSERVATIONS

The author is cognizant of the fact that these preliminary tests cannot be the basis of definite conclusions; however, some comparisons of the data gathered seem worthy of consideration and of further study.

*Different attenuations were used, so comparisons should not be made on the height of the stroke alone, but rather by the calibrated gram weight, as in Tables I and II.

TABLE II

ZERO CUSP

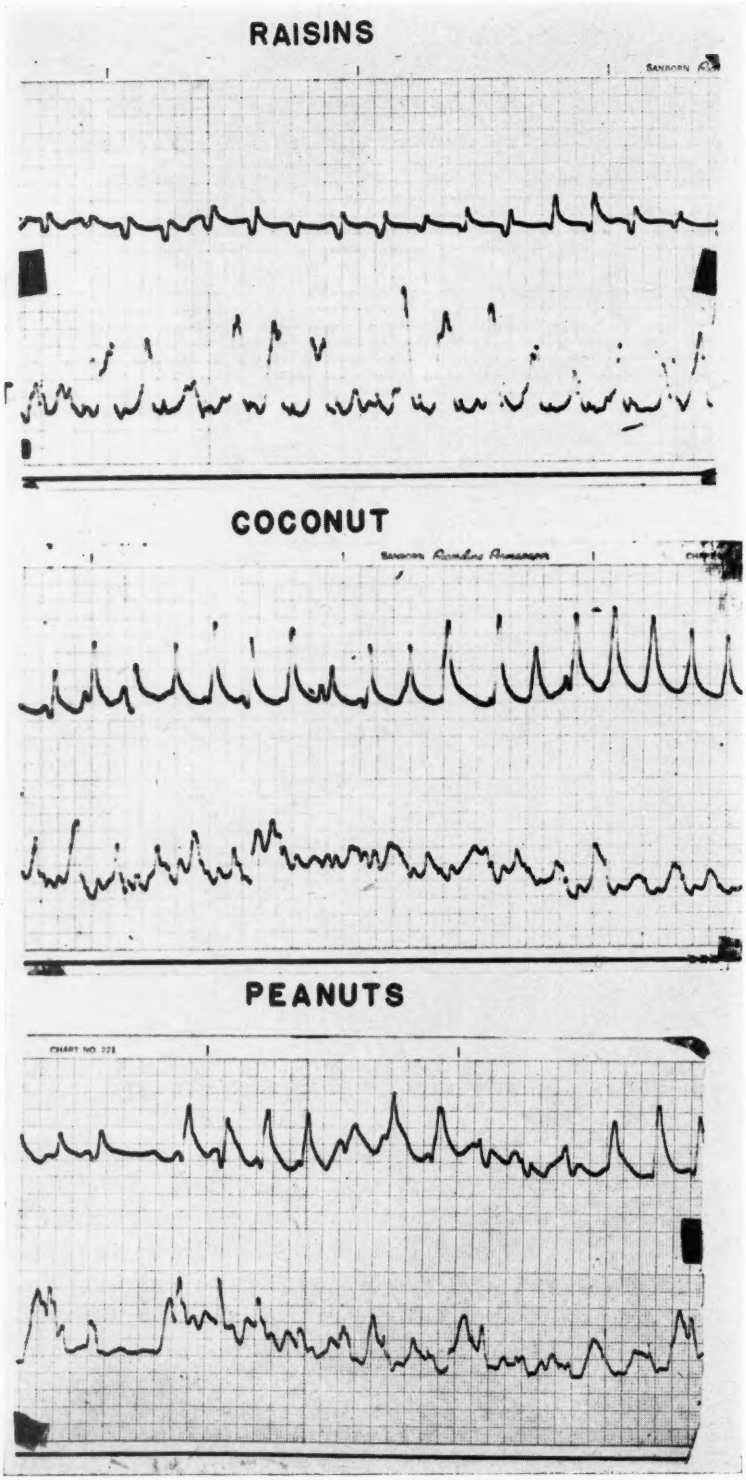
	WORKING (RIGHT)	BALANCING (LEFT)
Raisins		
Average	23.4	37.4
Minimum	15.6	13
Maximum	33.8	48.4
Peanuts		
Average	27.5	28.6
Minimum	15.6	16.5
Maximum	39	44
Coconut		
Average	30	27.5
Minimum	26	14
Maximum	36	38.5

ANATOMIC CUSP

	WORKING (LEFT)	BALANCING (RIGHT)
Raisins		
Average	19.2	18.7
Minimum	15.6	16
Maximum	26.4	22
Peanuts		
Average	15.6	15
Minimum	10.8	12
Maximum	18	22
Coconut		
Average	20.4	15
Minimum	12	12
Maximum	26.4	17

1. The strokes, particularly on the chewing side, are fairly uniform and fall into a definite rhythm pattern. This is true both when food is present and when mastication is simulated without food. On the first test run there was a slight rise and fall in the base line, but even so, the rhythm pattern was not destroyed. In the later tests taken with the Sanborn twin-viso equipment, this error in the base line was eliminated, and the recording speed was retarded so that more detail of the pattern could be shown. This suggests that further study could be made of the pressure pattern as associated to the masticatory cycle, both as to lateral and vertical pressure. It also emphasizes the comparative accuracy of the equipment used.

2. The patient in the first test was a large husky man. He masticated quite vigorously, usually beginning with quite a large bolus of food. His test indicated



Figs. 13.-16.—Recording from two patients with two gauges in position made with different foods and different dentures.

Fig. 13.—Anatomic cusp, *A*, *C*, and *E*, working left; *B*. *D*, and *F*, balancing right,

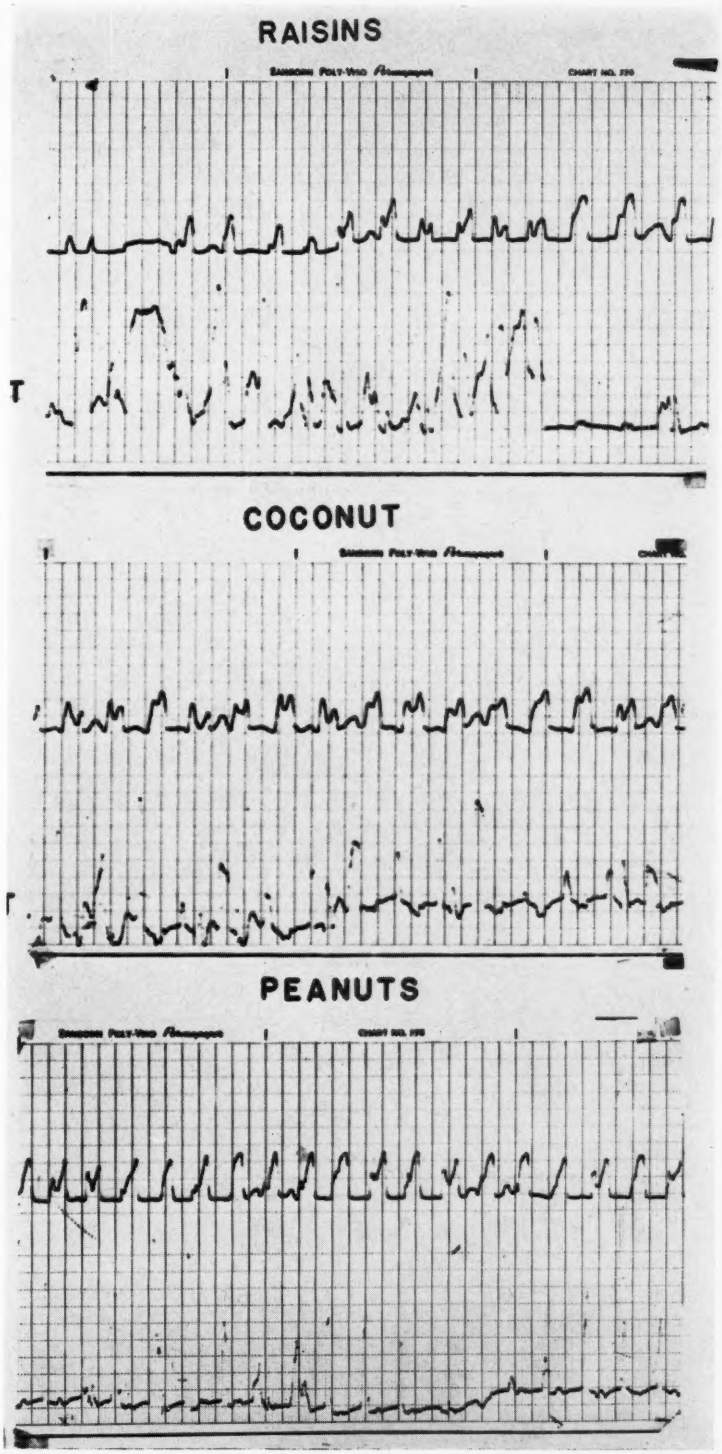


Fig. 14.—Zero cusp, *A*, *C*, and *E*, working left; *B*, *D*, and *F*, balancing right.

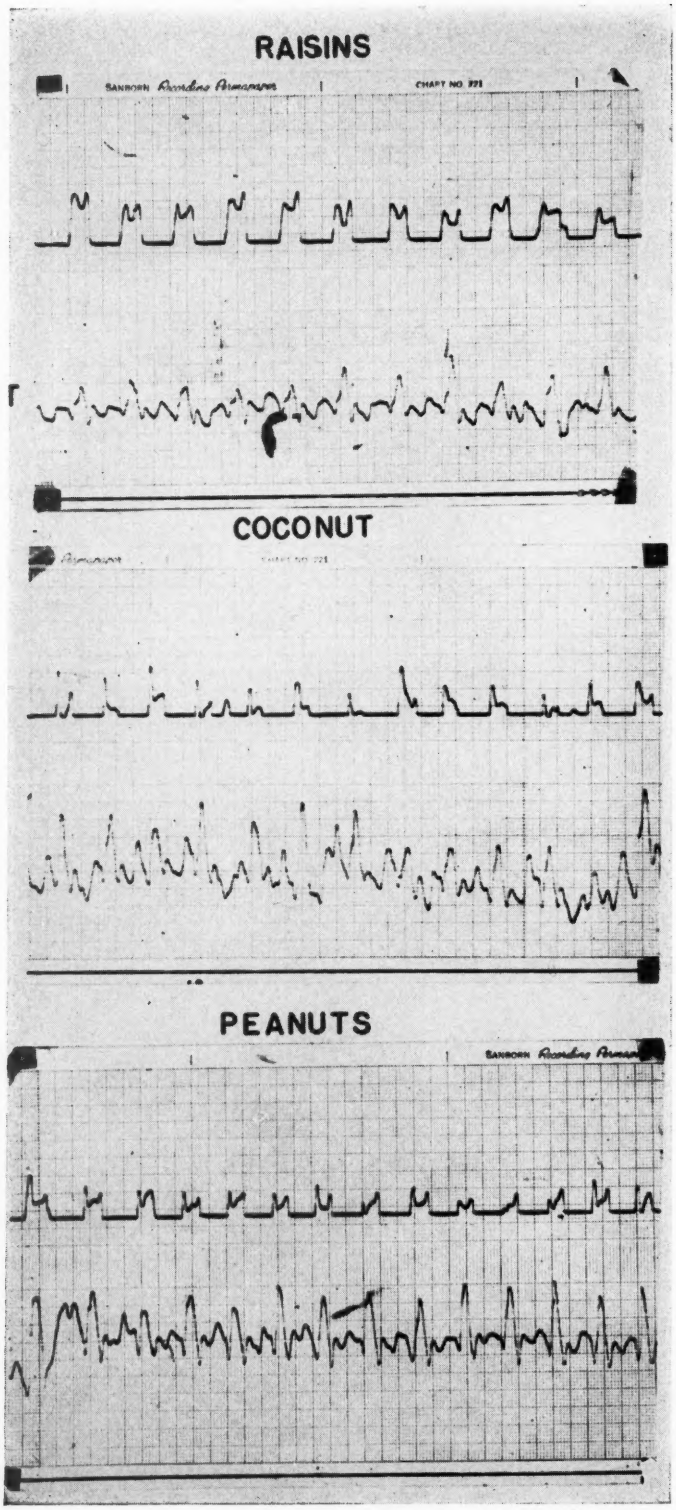


Fig. 15.—Anatomic cusp, *A*, *C*, and *E*, working right; *B*, *D*, and *F*, balancing left.

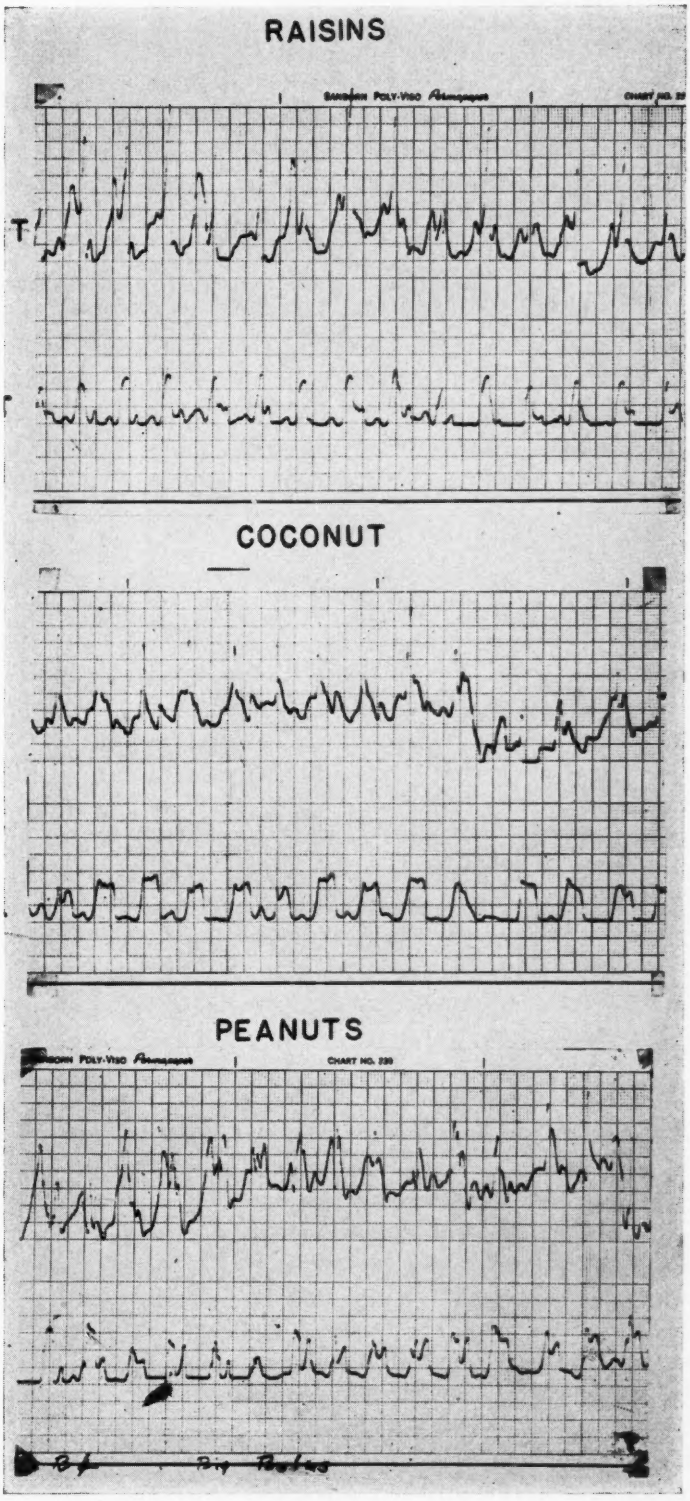


Fig. 16.—Zero cusp, *A*, *C*, and *E*, balancing left; *B*, *D*, and *F*, working right.

that the lateral pressures on the chewing side of the anatomic teeth exerted approximately twice as much pressure as zero cusp teeth. This seems to suggest at least one explanation for the results indicating superior efficiency of anatomic teeth over zero cusp teeth as found by Trapozzano[10] and Payne.[11]

The patient involved in the later test was a very small man who took small bites and masticated quite daintily. His test would indicate that the chewing side lateral pressures of the anatomic teeth were almost the same as, but slightly below, that of the zero cusp teeth.

3. In the first test, it is interesting to note that there is twice as much pressure on the chewing side of the anatomic teeth, not only in function, but also in the same movements without food interposed between them. When one considers, as Brudevold[15] stated, that a patient increases the strokes rather than the force of a stroke if there is any uncomfortable sensation, one would assume that this pressure on the chewing side was a comfortable pressure.

4. The so-called balancing side (probably more correctly called the nonchewing side) shows the zero cusp teeth to exert lateral pressures as high and even higher than those of the anatomic teeth. The first test with the patient with the vigorous bite showed the surprising comparison that, although the lateral pressure of the nonchewing side of the anatomic teeth was twice as great as the chewing side, in the zero cusp the nonchewing side was *five* times as great as its chewing side. When one considers that movements from right and left lateral to centric occlusion and protrusive to centric occlusion without food show the lateral forces on the nonchewing side to be much *less* than on the chewing with both zero and anatomic teeth, we can assume that there was no premature contact or imbalance on the nonchewing side. What pressures then are brought to bear to create such a tremendous pressure on the nonchewing side with the zero cusp teeth?

The later test with the patient with the more delicate bite showed the nonchewing pressures with the zero cusp teeth to be consistently slightly higher than that on the chewing side. The maximum pressures exerted on the nonchewing side occasionally were considerably higher than on the chewing side; whereas with the anatomic teeth, they tend to run approximately the same or even slightly less on the nonchewing side.

Whether or not these surprising pressures on the nonchewing side are the result of balancing contact, muscle and cheek pressures, or some other action by the patient is not in the province of this article to say. But I would raise the question: Is there a more rapid torque or rocking of the denture with zero cusp teeth which brings the nonchewing side into contact with so much more pressure than its chewing side?

5. Even though the foods were of different consistencies, there is still no appreciable difference in the comparisons of the nonchewing and chewing pressures for each; e.g., the nonchewing pressure for a specific food is approximately the same, or so many times the chewing pressure, for the same food with the same type of cusp.

6. It is recognized that some lateral pressure would be exerted by a vertical force (in fact, that is demonstrated in the vertical bite of Figs. 11 and 12). How-

ever, it is noticed on the readings taken from the second patient wherein both gauges on the chewing *and* nonchewing sides are recorded simultaneously show that the maximum pressure of both nonchewing and chewing sides are, for the most part, not exerted simultaneously on either the anatomic nor on the nonanatomic teeth. This suggests that there is considerable lateral shifting of the dentures during mastication. When we maintain that by eliminating cusps and by using nonanatomic teeth we are eliminating lateral pressures against the supporting tissue, it would appear that we have been building on a false premise. It has been shown that the nonchewing pressure is as great or much greater than the chewing pressure while using nonanatomic teeth. It is also evident that the chewing and nonchewing pressures do not occur simultaneously, but rather they occur first on the chewing side, then on the nonchewing side as the denture shifts laterally first to the right, then to the left.

SUGGESTIONS

1. It is believed that a means of measuring pressures of denture to tissues has been found, and also a means of approaching some of our denture problems from a more rational point of view may be developed. It suggests that some of our past conclusions may need re-evaluation. Further tests similar to these described should be made to complete the interpretation of the results.

2. In future tests, it is suggested that the efficiency of food breakdown should be checked along with the forces being applied.

3. The same tests could be carried out using other tooth forms.

4. The comparison should be made of a single tooth form by recordings made before and after various alterations in its form, such as the sharpening of cusps and the addition of sluiceways.

5. In the field of partial dentures, it would be interesting to note if the same forces are brought into action on the nonchewing side as has been demonstrated with complete dentures.

6. Comparative pressures could be recorded against the buccal (external) surface of a denture on both the chewing and nonchewing side to help determine what part the musculature of the cheeks plays in helping to balance and stabilize a denture.

CONCLUSIONS

A method for measuring pressures exerted against the supporting tissues by portions of a denture base has been described. Some preliminary comparisons have been made of the lateral pressure exerted in the buccal flange region above the upper first molars of dentures made with zero cusp teeth as compared with dentures made with anatomic teeth.

Because of the extreme complexity of the problem, it is emphasized that no concrete conclusions can be drawn at this time. It is hoped, though, that a new approach has been developed which will aid us, after study, to more easily distinguish between fundamentals and mere techniques.

It is quite understandable that in the past without methods of measuring the pressures of the denture base against the supporting tissue, we have had to draw certain assumptions and use these as a foundation for drawing other conclusions. It is the plea of this author that since the advent of the electronic strain gauge (which has been used for measuring forces in many other fields) that by adapting it to our needs we will change our approach and determine actually what is happening. Then by altering the conditions, and measuring again exactly what happens, perhaps we can begin to draw more rational conclusions. I am not even suggesting that this is necessarily the best method of measuring these pressures; however, it is one method, and may I plead again that we all give some thought and study to this approach to our problem.

This article was originally written as a thesis in partial fulfillment of the requirements for a Master of Science Degree in Denture Prosthesis while attending the School of Dentistry at the University of Michigan during the period of June, 1951, until June of 1953. I would like to express my appreciation to Dr. Floyd A. Peyton for his guidance of this project during that period, and particularly have I appreciated the technical assistance and encouragement of Edwin E. Henry, Jr., Ph.D. (in Electrical Engineering). Dr. O. C. Applegate and Dr. R. H. Kingery have offered many helpful suggestions and guidance.

Since June of 1953, this project has been carried on at the School of Dentistry at the College of Medical Evangelists in Loma Linda, California, and I am grateful to them for furnishing the equipment and allowing me to carry on this study.

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School of Dentistry,
College of Medical Evangelists,
Loma Linda, Calif.

ESSAY CONTEST

sponsored by

THE AMERICAN DENTURE SOCIETY

PRIZES WILL BE AWARDED to the two senior dental students who submit the best essays on prosthetic dentistry in the third annual essay contest sponsored by The American Denture Society. The purpose of the contest is to stimulate technical writing by dental students.

The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00).

RULES

1. The contest is open to all senior dental students in the dental colleges of the United States and Canada.
2. Only two essays may be submitted from any one dental college. (It is recommended that each dental college first conduct its own essay contest to determine the two best essays submitted by members of its senior class.)
3. All essays submitted in the contest shall be accompanied by a letter from the professor of prosthetic dentistry and/or the Dean of the dental college from which they originate. This provision is to assure the authenticity of all essays entered in the contest.
4. Essays must be postmarked on or before July 15, 1955 in order to receive consideration.*
5. Essays are to be on some phase of prosthetic dentistry and limited to a maximum of 2,500 words.
6. Essays must be worthy of publication in the Journal of Prosthetic Dentistry to qualify for a prize.
7. Essays must be typewritten, double spaced, on a good grade of white bond paper 8½ by 11 inches. No carbon copies or essays on onion skin paper will be considered. Paragraphs must be indicated clearly by indentations and generous margins must be allowed on each page.
8. Illustrations must conform to the standards of the Journal of Prosthetic Dentistry if they are used. Only good glossy black and white photographic prints or drawings in India ink may be used. Each illustration should be mounted on a separate sheet of paper with the Figure number and the legend typed on the paper beneath the illustration.
9. References must conform to the style used in the Journal of Prosthetic Dentistry.

*Beginning with the 1955-1956 contest the closing date will be March 1, 1956. It is recommended that students start preparing their essays by the middle of their junior year and complete them by the middle of their senior year.

10. Essays are to become the property of The American Denture Society and none will be returned.
11. The judges of the contest are members of a special committee of The American Denture Society. The decision of the judges is final.
12. Essays are to be clearly marked "Contest Essay" and sent, along with a letter from the professor of prosthetic dentistry or the Dean of the dental college indicating that this essay is an official entry from that that dental college, to:

Dr. Carl O. Boucher
Editor, Journal of Prosthetic Dentistry
College of Dentistry, Ohio State University
Columbus 10, Ohio.

For further information write to: Dr. Arthur L. Roberts, Secretary, American Denture Society, Aurora Main Building, 4 Main Street, Aurora, Illinois.

News and Notes

ANNOUNCEMENTS

The Academy of Denture Prosthetics will hold its next meeting at the Statler Hotel in New York City, May 2 to 6, 1955.

The American Association for Cleft Palate Rehabilitation will hold its Thirteenth Annual Meeting at the Statler Hotel in Boston, Mass., May 13 and 14, 1955.

The Annual Post College Assembly of The Ohio State University College of Dentistry will be held April 20 and 21, 1955. The program will be of interest to the general practitioner.

The Division of Graduate and Postgraduate Studies of Tufts College Dental School will conduct the Sixth Annual Berkshire Conference in Periodontology and Oral Pathology at Eastover in Lennox, Mass., June 19 to 23, 1955. The Conference will consist of four days of lectures, seminars, and panel discussions regarding clinical problems by outstanding teachers and clinicians in dentistry, medicine, and their related fields. A special feature of the Conference will be a clinicopathologic seminar with microscopes provided for all participants.

The curriculum is arranged so that mornings and evenings are devoted to professional activities with afternoons open for recreation. This is a conference for general practitioners as well as those interested in a specialized practice.

Included in the faculty are: C. D. Marshall-Day, D.M.D., Reidar F. Sognnaes, D.M.D., Harry Sicher, M.D., Joseph Bernier, D.D.S., Paul Boyle, D.M.D., Irving Glickman, D.M.D., Benjamin E. Etsten, M.D., Edward H. Kass, M.D., George Stewart, D.D.S., Stanley Tylman, D.D.S., and Oliver C. Applegate, D.D.S.

For further information and application write to: Sixth Annual Berkshire Conference, Tufts College Dental School, 136 Harrison Ave., Boston, Mass.

The teaching Division of the Dental Department of the Beth Israel Hospital announces a two week conference and seminar in Periodontology from May 9 to 20, 1955.

For further information, write to the Coordinator of Education Programs, Beth Israel Hospital, 330 Brookline Ave., Boston 15, Mass.

Loyola University, Chicago College of Dental Surgery announces a course in "Applied Anatomy" which will be taught by Harry Sicher, M.D., on March 24, 25, 26, 1955.

The lectures will be given at the cadaver while the respective region is being dissected. Special emphasis will be given to clinical application. The following regions will be covered: triangles of the neck, muscles of facial expression, parotid gland, facial nerve, muscles of mastication, infratemporal fossa, pharynx and larynx, tracheotomy, and coniotomy, cranial base, nasal cavity, nasal sinuses and oral cavity.

For information please write to Dr. F. M. Wentz, Director Postgraduate Division, 1757 West Harrison Street, Chicago 12, Ill.

The American Dental Assistants Association, in a recent meeting in Miami, approved the course plan of the University of North Carolina Extension Division. This correspondence course with twenty-five lesson assignments permits the dental assistant to accomplish study and exercises at home and at the office laboratory. The course is designed to be a challenge to the newcomer as well as the veteran dental assistant, and it was developed through the cooperation of the Dental Assistants Committee of the North Carolina Dental Society and faculty at the University. More than 100 girls now are pursuing the course, thereby satisfying the educational requirements in preparation for the Certification Examination of the American Dental Assistants Association. The tuition, including all materials from the Extension Division, is $50.00. Further information may be secured or enrollment may be accomplished by writing the Extension Division, University of North Carolina, Box 1050, Chapel Hill, N. C.

The School of Dentistry, University of Pennsylvania announces several postgraduate courses of interest to prosthodontists.

Complete Denture Prosthesis, Victor Lucia, March 28 to April 2, 1955.

Clinical Application of the Principles of Crown and Bridge Service, Ernest B. Nuttall, April 11 to 16, 1955.

For further information, write to the Director, Postgraduate Courses, School of Dentistry, University of Pennsylvania, 4001 Spruce St., Philadelphia 4, Pa.

The College of Dentistry, Ohio State University announces several postgraduate courses of interest to prosthodontists.

Crown and Bridge, Frank C. Starr, March 21 to 25, 1955.

Complete Denture Prosthesis, Carl O. Boucher, April 4 to 8, 1955.

Anatomy of the Head and Neck, Linden F. Edwards, June 6 to 10, 1955.

For further information write to Director, Postgraduate Courses, College of Dentistry, Ohio State University, Columbus 10, Ohio.

Tufts College Dental School announces several postgraduate courses of interest to prosthodontists.

DPG. 702—Immediate Upper and Partial Lower Denture Prosthesis, Irving R. Hardy and Staff, each Tuesday for six weeks from April 5 to May 17, 1955. Class suspended April 19th.

DPG. 703—Full Denture Prosthesis, Irving R. Hardy, May 23 to June 3, 1955.

DPG. 712—Full Denture Implants, Norman I. Goldberg and Aaron Gershkoff, April 25 to 29, 1955.

For further information, write to the Director, Graduate and Postgraduate Courses, Tufts College Dental School, 136 Harrison Ave., Boston, Mass.